



Clean Sky 2 Joint Undertaking

Work Plan 2014-2015

Important Notice on the Clean Sky 2 Joint Undertaking (JU) Work Plan 2014-2015

This Work Plan covers the years 2014 and 2015. Due to the starting phase of the Clean Sky 2 Joint Undertaking under Regulation (EU) No 558/204 of 6 May 2014 the information contained in this Work Plan (topics list, description, budget, planning of calls) may be subject to updates. Any amended Work Plan will be announced and published on the JU's website.

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- July 2014 -

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1. CLEAN SKY 2 JU - INTRODUCTION

Clean Sky Public Private Partnership

Clean Sky today epitomises a true Public Private Partnership (PPP). It represents a strategic and successful input to the Europe 2020 objectives: boosting private investments in research and innovation and making the best use of public research funding in a vital and growing sector. Five years into the Programme, the step-change improvement potential targeted, such as up to 30% reduction in CO₂ emissions and (depending on the aircraft segment) 60% reduction in noise footprint, are all within reach. Stakeholder participation is a huge success: first time participation from many SMEs and their success rate in the Calls for Proposals is over twice that of any other FP7 instrument. Industry is increasingly using *Clean Sky* as the centrepiece of their R&T programmes because of the flexibility of the instrument; and the JU has proven its efficiency as a management body.

Horizon2020 and Clean Sky 2: new challenges and objectives

This is one of the reasons why the European Commission proposed in July 2013, within the European Innovation Investment Package, to continue *Clean Sky* in the framework of Horizon 2020: a *Clean Sky 2* Regulation was built to address the **Joint Technical Proposal** put together by the leading companies, “founders” of *Clean Sky 2* and coordinated by the JU. Regulation No 558/204 of 6 May 2014 establishing the *Clean Sky 2* Joint Undertaking was adopted by the Council on 6th of May, 2014 after consultations with the European Parliament and published on the 7th of June 2014¹.

The aeronautical sector, in particular through *Clean Sky 2*, will be a critical player in contributing to one of the key Societal Challenge ‘*smart, green and integrated transport*’ defined in **Horizon 2020**. The *Clean Sky 2* Programme will serve society’s needs and strengthen global industry leadership. It will enable cutting edge solutions for further gains in decreasing fuel burn and CO₂ and reducing NO_x and noise emissions. It will contribute strongly to the renewed ACARE SRIA².

Clean Sky 2 will be more than twice the size of *Clean Sky*, with widened scope and objectives: higher level of integration of technologies while taking also into account some lower-TRL, longer-term targets; reaching for a new set of environmental targets – assuming that those of the current *Clean Sky* will actually been achieved as expected – while ensuring the future global leadership of the European industry and supply chain, creating jobs through a reinforced competitiveness.

Clean Sky 2 will build on the success of *Clean Sky* and will deliver full-scale in-flight

¹ OJ L 169/77 of 7 June 2014.

² Advisory Council on Aviation Research in Europe, Strategic Research and Innovation Agenda (2012)

demonstration of novel architectures and configurations. Advanced technology inserted and demonstrated at full systems level will enable step-changes in environmental and economic performance and bring crucial competitiveness benefits to European industry. By *jointly* pursuing this research on new breakthrough innovations and *demonstrating* new vehicle configurations in flight, the Programme will provide the proving grounds for concepts that would otherwise be beyond the manageable risk of the private sector. It will give the necessary funding stability to the private sector to develop and introduce game-changing innovations within timeframes that are otherwise unachievable. Compared to the best available aircraft in operation in 2014, up to a 30% reduction in fuel burn and related CO₂ emissions, similar or greater reductions in NO_x emissions and up to a 75% reduction in noise affected communities will accrue from this focused and programmatic approach. These pace-setting gains will enable the European Aviation Sector to satisfy society's needs for sustainable, competitive mobility towards 2050. By doing this, *Clean Sky 2* will be *the key European instrument* to speed up technology development, overcome market failure and guarantee a sustainable advancement of aviation. *Clean Sky 2* will significantly contribute to the Innovation Union, create high-skilled jobs, increase transport efficiency, sustain economic prosperity and drive environmental improvements in the global air transport system.

The *Clean Sky 2* Programme will be jointly funded by the European Commission and the major European aeronautics companies, and will involve an EU contribution from the Horizon 2020 Programme budget of €1.755 bn. It will be leveraged by further activities funded at national, regional and private levels leading to a total public and private investment of approximately €4 bn. *Clean Sky 2* will run for the full duration of Horizon 2020 actions, i.e. from 2014 to 2023. A phased approach will be taken to the start-up of *Clean Sky 2* projects and align them closely and adequately with *Clean Sky* on-going projects (to be completed in the period 2014-2016). It will be endorsed and supported by the leading European aeronautic research organisations and academia. Small and medium-size enterprises and innovative sub-sector leaders will continue to shape promising new supply chains. In so doing, *Clean Sky 2* will engage the best talent and resources throughout Europe and over 3,000 highly skilled staff (FTEs) will be consistently employed over a ten year period.

PART A – *CLEAN SKY PROGRAMME*

2. INTRODUCTION TO THE PROGRAMME

The Council Regulation setting up the Joint Undertaking was adopted by the Council of the European Union on 20 December 2007 and published in the Official Journal of the European Union on 4 February 2008.

Clean Sky is a Joint Technology Initiative (JTI) that aims to develop and mature breakthrough ‘clean technologies’ for Air Transport. By accelerating their deployment, the JTI will contribute to Europe’s strategic environmental and social priorities, and simultaneously promote competitiveness and sustainable economic growth.

Joint Technology Initiatives are purpose-built, large scale research projects created by the European Commission within the 7th Framework Programme (FP7) in order to allow the achievement of ambitious and complex research goals. Set up as a Public Private Partnership between the European Commission and the European aeronautical industry, Clean Sky pulls together the formidable research and technology resources of the European Union in a coherent, €1.6 bn programme.

The Clean Sky goal is to identify, develop and validate the key technologies necessary to achieve major steps towards the ACARE (Advisory Council for Aeronautics Research in Europe) Environmental Goals for 2020 when compared to Year 2000 levels: fuel consumption and carbon dioxide (CO₂) emissions reduced by 50%, Nitrous oxides (NO_x) emissions reduced by 80%, reduction in perceived external noise of 50% ; another goal is to improve the environmental impact of the life cycle of aeronautical products (manufacturing, operation, maintenance and disposal).

Simultaneously, the programme aims to strengthen and anchor industrial competitiveness in the European Aeronautical industry by enabling an accelerated development and validation of differentiating technology, enduring networks of research collaboration and innovation, and a stable platform for integration and synthesis of technology into viable development platforms.

Clean Sky activities cover all sectors of the Air Transport System and the associated underlying technologies.

Clean Sky is built upon 6 different technical areas called Integrated Technology Demonstrators (ITDs), where preliminary studies and down-selection of work will be performed, followed by large-scale demonstrations on ground or in-flight, in order to bring innovative technologies to a maturity level where they can be applicable to new generation “green aircraft”. Multiple links for coherence and interfaces are ensured between the various ITDs.

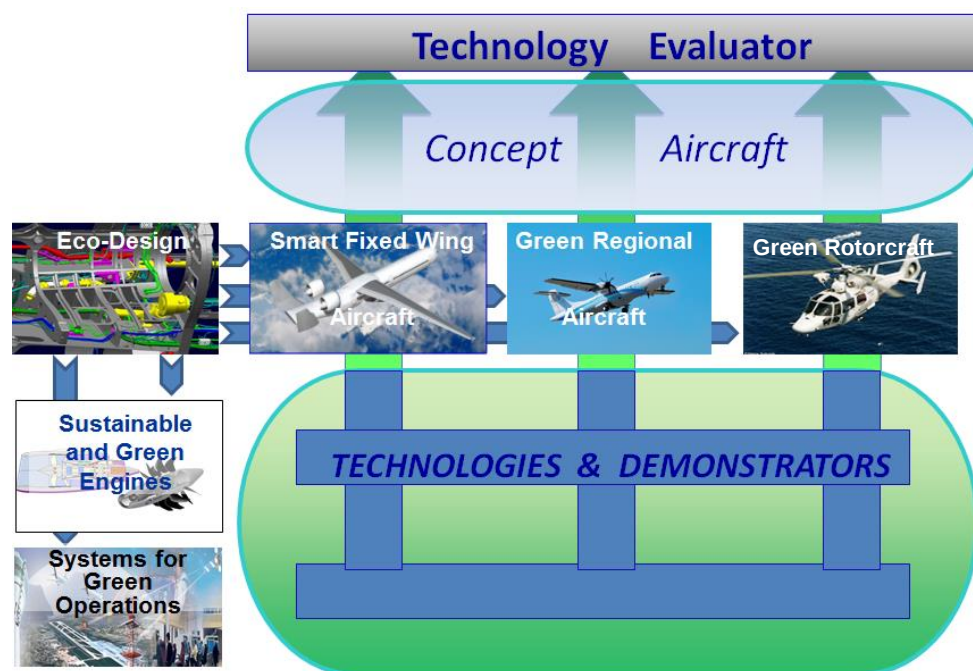
A “Technology Evaluator”, using a set of tools at different levels of integration, from the single aircraft mission to the worldwide fleet, provide for independent evaluation of the

environmental achievements. The innovative technologies developed by Clean Sky cover nearly all segments of commercial aviation.

Innovative technologies, Concept Aircraft and Demonstration Programmes form the three complementary instruments used by Clean Sky in meeting these goals:

- Technologies are selected, developed and monitored in terms of maturity or ‘Technology Readiness Level’ (TRL), the ultimate goal of Clean Sky is to achieve TRLs corresponding to successful demonstration in a relevant operating environment (i.e. TRL 6). This is the highest TRL achievable in research.
- Concept Aircraft are design studies dedicated to integrating technologies into a viable conceptual configuration. They cover a broad range of aircraft: business jets, regional and large commercial aircraft, as well as rotorcraft.
- Demonstration Programmes include physical demonstrators that integrate several technologies at a larger ‘system’ or aircraft level, and validate their feasibility in operating conditions. This helps determine the true potential of the technologies and enables a realistic environmental assessment. Demonstrations enable technologies to reach a higher level of maturity (TRL).

The Clean Sky Programme is shown schematically in the following figure:



The multi-annual approach

Most of the Clean Sky full-scale, in-flight demonstrations will be taking place from 2014 to 2016.

Based on the multi-annual commitments approach of Clean Sky 2 under its new legal basis, this work plan includes a full description of activities for the years 2014 and 2015. As many activities are interlinked with previous years' work and tests performed, there are mentions of other years throughout this document in order to give the complete picture to the reader.

The period 2014 to 2016 will represent the peak of the Clean Sky programme with most of the demonstration activities taking place. All Integrated Technology Demonstrators (ITDs) will experience an intense activity:

- Most key technologies have been completed for integration in demonstrators that will enter the phase of detailed design, manufacturing and testing.
- Should however some ITDs fail to use in due time the full funding available, due to any technical contingencies, some further technologies may be introduced in several integrated demonstrators.
- The evaluation results of the call 16 which took place in December 2013 enabled the JU to have a clear picture of the target to reach (minimum 200 m € to be granted to partners arising from the calls process).

3. CLEAN SKY PROGRAMME IMPLEMENTATION 2014 - 2015

3.1. SFWA – Smart Fixed Wing Aircraft

SFWA is developing two major large transport aircraft technologies; the first mainly related to the drag reduction by using laminar flow and known as 'smart wing', and the second related to the integration of advanced (ultra-) high bypass propulsion concepts such as Open Rotor. The objective is to achieve maturity levels in both technologies to a status close to a potential application through major, dedicated large scale ground and flight demonstrations.

Activities for year 2014

Overview

The SWFA ITD is heading towards the stage of implementation and testing of these technologies through demonstration both in laboratory and in flight. As consequence, most of the work in 2014 will be dedicated to prepare and to conduct large ground and flight test demonstrations along the main technology streams, namely the natural laminar flow wing, the smart flap for low speed applications, low speed vibration flight demonstration, the business jet innovative after body demonstrator, as well as simulator tests and flight tests for active load control for large passenger aircraft and vibration control for business jets.

Final wind tunnel tests for the integration of the CROR propulsion are foreseen on selected issues of high speed performance, acoustics and handling quality. The identification and qualification of structural solutions for the engine integration and to manage potential failure cases will be continued. Based on the expected availability of a first set of CROR engine certification and qualification rules, related test activities will be launched in 2014.

Based on specifications made in 2013 and in close coordination with the SAGE-ITD the formal preliminary design review process for the CROR demo engine integrated to an Airbus test aircraft based flying test bed will start in summer 2014 with a significant number of dedicated component and system preliminary design activities. The baseline for the test aircraft is an Airbus A340-300.

Tests to down select passive and active means to control buffet will be conducted through most of 2014 to targeting for a technology readiness level of TRL4 at the end of 2014.

The preparation of the Airbus A340-300 BLADE test aircraft will require a strong effort in terms of man power and resources along all the 2014. Paralleled by the work to assemble the upper cover and leading edge parts of the laminar wing articles in Vitoria (at Aernnova), planned to start in June 2014, the first wing shall arrive in the hangar with the test aircraft in June 2014. The huge working party of the test aircraft is planned to begin at the end 2014, with ground tests planned to start in April 2014. The aircraft is booked to be exclusively available for the BLADE working party, flight test campaign and refurbishment from June 2014 until autumn 2016.

In parallel to the BLADE flight test, the “Phase 4 smart laminar wing ground based demonstrator” (GBD) will be assembled to validate key features of the laminar wing structural concept at large scale, in particular the integration of the leading edge, upper cover and the Krueger-based high lift components.

Major milestones planned for 2014:

- Start of the laminar wing BLADE Airbus A340-300 working group
- Complete the leading edge system demonstrator
- Pass the Low Speed Business Jet “Smart Flap” Critical Design Review
- Launch the simulator tests for active load control functions large transport aircraft
- Launch the simulator tests for vibration control tests for business jets
- Prepare the CROR engine demo Airbus A340-300 test aircraft Preliminary Design Review process
- Launch of preliminary design phase for CROR-Pylon
- Complete the SFWA principle contribution to CROR-engine integration rulemaking process
- Complete the preparation of Innovative Bizjet afterbody wind tunnel flutter test
- Complete the in-flight CROR blade deformation and CROR –pylon effort measurement system definition

Major deliverables planned for 2014:

- Delivery of the Portboard laminar wing Upper Cover and leading edge for wing assembly
- Starboard and Portboard laminar wing test article on dock at BLADE final assembly line
- Blade fuselage Pod on dock at BLADE final assembly line
- Complete the laminar Wing Ground Based Demonstrator Phase 4 assembly
- Analysis and Completing of the Smart Flap Low Speed Business-Jet (LSBJ) Wind tunnel test
- Complete the application of aeroelastic and aerodynamic tailoring on concept aircraft
- Pass the test of the Critical Design Review for Low Speed Vibration Control of Business Jets
- Definition of the principle architecture of CROR demo–engine system integration to Airbus A340-300 FTD
- Complete test plan for impact & trajectory tests
- Large scale Innovative Bizjet afterbody demonstrator assembled, ready for test
- Definition of the in-flight PIV diagnostic concept for CROR demo-engine flight test, integration concept for test aircraft available
- Delivering of the PANEM model of CROR powered short and medium range transport aircraft including key system features from SGO-ITD.

Activities for year 2015

Overview

The preparation of the main demonstrators of the SFWA technologies will be completed at straddling the end of the year 2014 and the beginning of year 2015. Hence the activities in 2015 will focus for the majority on performing tests on large ground and flight demonstrators, such as the natural laminar flow wing, the smart flap for low speed applications, low speed vibration flight demonstration, and the business jet innovative after body demonstrator.

All major components for the Airbus A340-300 BLADE flight test demonstrator are scheduled to arrive in the first half year of 2015 “on dock” at the final assembly hangar in Tarbes, which will be exclusively dedicated for the preparation, maintenance, conduct and refurbishment activities for a period of, in total, two years. The laminar test wing articles are planned to arrive by end of the second quarter of 2015, shipped to Tarbes directly after completion of the assembly in Vitoria (Spain). Component assembly, installation of flight test instrumentation, calibration and ground tests of all major BLADE wing components will stretch over the second half of 2015, finishing into 2016.

The ground based demonstration associated to the development of the laminar wing for large transport aircraft, which is going on in parallel, will be concluded in early 2015 with a number of key contributions to TRL5 to the structural concept and the leading edge high lift kinematic.

The low speed vibration load control tests for business jets in 2015 will encompass all major simulator tests and tests with the full size Dassault Falcon ground rig. Parallel tests with advanced load control functions integrating real time loads monitoring will be conducted with target to accomplish technology readiness levels of 5 at the end of 2015 for Business jets and large passenger short range aircraft.

The so-called “smart flap”, a multifunctional control surface with extended high lift and flight control capability for business jets will be tested in a full size ground demonstrator over the full domain of static and dynamic loads relevant for a the flight envelope in the second half of 2015. The analysis and exploitation of tests is scheduled to follow in 2016.

For the innovative rear empennage for business jets, the flutter test will be conducted in a high speed wind tunnel test and will be a key contribution to reach TRL4. The full scale ground test with a structural mock up is planned to take place behind a Dassault Falcon 7X to obtain realistic data about the thermal, acoustic and fatigue behaviour of the advanced V-tail concept, which shall lead to the accomplishment of TRL 5 before the end of 2015.

Most of the research and development activities for the Contra Rotating Open Rotor will be transferred to the Clean Sky 2 programme, while a number of topics (assigned by Call for proposal) concerning the propulsion system integration, the aerodynamic and acoustics, certification items, the physical integration and flight test, as well as the demonstration and instrumentation, will continue in SFWA during 2015. A significant number of related conclusive results are expected in 2015, to be completed in 2016.

In 2015 all SFWA activities associate to active flow control wing technologies are planned to be completed with the final testing of the robustness of the developed actuator concepts under

operational conditions. A final analysis of experiments done in 2014 on the leading edge contamination effect for the application of hybrid laminar flow control, and a number of wind tunnel tests of active and passive buffet control technologies will be done in SFWA in 2015.

Major milestones planned for 2015:

- Dedicated dock and hangar ready to host the BLADE test aircraft;
- Start of the final assembly of the BLADE Airbus A340-300 test aircraft with all major components;
- Integration of Laminar wing test results for large passenger aircraft into a next generation short range aircraft concept;
- Completing of Low Speed Business Jet “Smart Flap” ground test campaign;
- Completing of simulator tests for active load control functions large transport aircraft;
- Completing of simulator tests for vibration control tests for business jets;
- Completing of buffet control technology wind tunnel tests;
- Completing of CROR shielding concept studies for primary structures;
- Availability of CROR-engine integration strategies and rules (result of coordinated action of SFWA and beyond, including relevant authorities);
- Completing of smart flap demonstrator structural integration;
- Starting of the test campaigns to develop and test In-flight CROR blade deformation measurement system based on “IPCT” and flow diagnostics based on “phase locked “PIV”;
- Completing of mid-scale validation wind tunnel tests of active flow control concept.

Major deliverables planned for 2015:

- Port and starboard laminar wings delivered on dock at BLADE final assembly line;
- Wing diffusion zones, aero-fairings, wing tip pods and plasterons delivered on dock at BLADE final assembly line;
- Delivering of all major components for BLADE flight test instrumentation to final assembly line;
- Completing of the leading edge “phase 4” demonstrator tests, results analysed;
- Completing of the Laminar Wing Ground Based Demonstrator Phase 4 assembly;
- Completing of the Smart Flap Low Speed Business-Jet (LSBJ) high Reynolds number aero performance tests. Completing and analysis of the Wind tunnel tests;
- Passive load control technology development and tests, preliminary results available;
- Starting of the large scale Innovative Bizjet afterbody demonstrator campaign;
- Simulator results to configure the for Low Speed Vibration Control of Business Jets ground test;
- CROR low speed test campaign with “Z49” package 1 test results;
- Completing of the CROR related impact & trajectory tests, preliminary results available;
- Completing of the Innovative Bizjet afterbody wind tunnel flutter test preliminary results available;

- Definition of the in-flight PIV diagnostic concept for CROR demo-engine flight test, integration concept for test aircraft available;
- PANEM model of CROR powered short and medium range transport aircraft including key system features from SGO-ITD updated with recent results accomplished in SFWA.

3.2. GRA – Green Regional Aircraft

Future green regional aircraft will have to meet demanding weight reduction, energy and aerodynamics efficiency, a high level of operative performance, in order to be compliant regards to pollutant emissions and noise generation levels. Objective of the Green Regional Aircraft ITD is to mature, validate and demonstrate the technologies best fitting the environmental goals set for the regional aircraft entering the market in the years 2015 - 2020. The project has 5 main domains of research, in which several new technologies are under investigation in order to entirely revisit the aircraft in all of its aspects. The GRA technological areas structure is as follows:

- GRA1 - Low Weight Configuration (LWC)
- GRA2 - Low Noise Configuration (LNC)
- GRA3 - All Electric Aircraft (AEA)
- GRA4 - Mission & Trajectory Management (MTM)
- GRA5 - New Configuration (NC)

GRA will continue the work packages defined in the baseline program, with internal review of the technologies to be further enhanced. Main GRA ITD activities, in the period 2014 – 2016, will be largely involved in design, manufacturing and final testing of the demonstrators, according to the description given below. For every domain, a short summary of the activities carried out for the 'mainstream' technologies in 2013 is here presented, with the scope of introducing the activities planned for the next biennium 2104-2015.

Activities for year 2014

Overview

GRA1 did significant effort, in 2013, and made further progress on the development of advanced composite materials. The design of the sections of the: Fuselage, Wing Box and Cockpit of the Full Scale Ground Demo have been completed, so that, on 2014, activities will mainly focus on the manufacturing of these Ground Demos. It has been also planned to start the design and manufacturing of the Upper Crown Panel to be used for flight tests. In detail, during 2014, the tests needed to achieve the Permit to Flight will be performed; the ground demonstrators and the Panel to be tested in flight will be manufactured. In order to perform, ATR In Flight Demonstration in 2015, structural and Systems modifications on the ATR 72 aircraft will be performed during 2014.

Most of the activities performed in 2013 by Low Noise Configuration domain (GRA2) concerned the development of the technologies to reduce the Main and Nose Landing Gears noise of the Turboprop 90-seat A/C, as well as, the development of advanced aerodynamics and load alleviation technologies for both 130-seat and 90-seat Aircraft Configurations. These concepts will be experimentally investigated by large wind tunnel tests. The activities planned during 2014 will concern the design and the preparation of these aerodynamics and

acoustic experiments. In particular, the demonstration of the Laminar Flow technology and load alleviation technique on an elastic wing is planned to start at end of 2014 in the frame of project ETRIOLLA under CfP. Design, preparation and execution of acoustic wind tunnel experiments on a Nose Landing Gear 1:1 scaled mock-up, to test devices for noise reduction will be performed during 2014.

GRA3 2014 activities will mainly focus on the completion of the studies on A/C integration of on-board systems, technologies enabling the application of the All Electric Aircraft concept, such as: the “E-ECS”, the “Advanced EPGDS” including technique for the “Electric Energy Management (E-EM)”, and the “Electromechanical Actuation (EMA)” for Flight Control and Landing Gear Systems. In 2014, AEA will also contribute to EDS Copper Bird activities for the Laboratory Electrical Testing of the Regional A/C configuration including EPGDS and EMA.

Most of the activities planned by Mission and Trajectory Management (MTM) domain during 2014 will concern the development of the Green Flight Management System (FMS) and of the realistic Regional Flight Simulator. The flight simulator will be configured, during this year, to simulate the GRA TP90 passengers. This will allow performing Flight Simulation Demonstration in 2015.

The activities performed by New Configuration domain, during 2014, will be concerning the design of a wind tunnel Test Campaign to demonstrate and validate the high-lift performance and the whole stability & control dataset of the 130-seat Regional A/C. A powered complete model will be used for these investigations. In addition, the sizing of two Green Concepts, TurboProp 90 pax and 130 pax with different powerplants (Advanced-TurboFan and Geared TurboFan Engines) will be initiated and continued through Loop 3 during all 2014. The A/C Simulation Models (GRASM) to the Technology Evaluator for the assessment of environmental targets achievement in terms of air pollutants emission (CO₂ & NO_x) and external noise reduction will be developed during this year to be finalized in 2015.

Major milestones planned for 2014:

- TRR Full Scale Demonstrator;
- Upper Crown Panel for the In-Flight Demonstration availability;
- NLF wing 1:3 Wind Tunnel model (HW) (ETRIOLLA project under CfP);
- WTT First Complete Aerodynamic Test (Clean Wing);
- Final Green FMS availability;

Major deliverables planned for 2014:

- Fuselage Test Article Availability;
- Wing Box Test Article Availability;
- Cockpit Test Article Availability;
- Test Set-Up & FCS-EMA Delivery for Copper Bird;
- Test Set-Up & LGS-EMA Delivery for Copper Bird;
- Electrical Power Generators and Controls equipment available for Demo Aircraft;

- Electrical Power Center (EPC) and Simulated Resistive Electrical Load available for Demo Aircraft;
- Completion of WT Testing of elastic modular transonic laminar wing model with load control devices (WTT2);
- Completion of LG Modular Scale WT Testing;
- NLG/MLG & Bay Concept: 2nd down selection;
- Green FMS final release availability;
- GRASM (TP90 pax and GTF 130 pax A/C of Design Loop 3).

Main events:

- TRR Full Scale Ground Demo;
- Test A/C available (ATR MSN 098);
- GRA Annual Review Meeting (ARM).

Work plan for year 2015

Overview

Low Weight Configuration domain (GRA1) activities will totally focus on Testing the Ground Demonstrators (Fuselage Section, Wing Box Section and Cockpit Section). The major objectives in 2015 are represented by the static and fatigue tests to be executed on Ground Demonstrators together with some functionality testing (i.e electrical conductivity, modal analysis and acoustic). Structural and Systems modifications will continue to be applied on the ATR 72. A new composite stiffened panel will be installed on crown area in place of the existing aluminium panel for flight tests. Pre-Flight Tests (preliminary strain check, acoustic evaluation and calibration of sensors for SHM) and Flight Tests will be executed, with unmodified and modified A/C, on ATR 72 (MSN 098). The overall assessment of the domain project results will be carried out including the final demonstrations results, focusing on the main achievements against initial targets. The Flight Readiness Review (FRR) will be achieved and the Flights will be executed in 2015.

Low Noise Configuration domain (GRA2) activities will be basically dealing with the demonstration of advanced aerodynamics (laminar flow technology), load alleviation (tests performed on 1:7 half-A/C aero-servo-elastic model in the frame of project GLAMOUR under CfP) and low airframe noise technologies tailored to 130-seat A/C (tests of low-speed aerodynamic and aero-acoustic performance on 1:7 complete A/C powered WT model in the frame of the projects: ESICAPIA and EASIER both under CfPs) and 90-seat green regional A/C (tests of low-speed aerodynamic and aero-acoustic performance on 1:7 complete A/C powered WT model) and acoustic tests performed on a full-scale mock-up of a Main Landing Gear low-noise configuration. Respective tests will be executed in the frame of the projects LOSITA, WITTINESS and ARTIC, all under CfPs, through a variety of large-scale aerodynamic and aero-acoustic Wind Tunnel Tests on innovative models.

In addition, mechanical tests on a full-scale prototype of the morphing flap sized to the half-outboard flap of the 130-seat A/C will be carried out. Ground demo of LC&A system architecture through a representative test rig integrating real-time computer, active devices and control laws will be performed. Then, the overall assessment of the domain project results will be carried out by reviewing the different phases of the work programme, from the technologies development to the final demonstrations, focusing on the main achievements against initial targets.

Most of the activities performed in Mission and Trajectory Management domain will be dedicated to the final Flight Simulation Demonstration test according to the defined procedure. The overall assessment of the domain project results, collecting pilot feedback and environmental benefit due to the implementation of green FMS functions, will be carried out. Demonstration of the Green FMS (Flight Management System), using a realistic Regional Flight Simulator, will be executed.

New Configuration domain (GRA5) will focus on the low-speed aerodynamic wind tunnel test campaign to estimate the performance in high lift conditions of the 130-seat aircraft configuration by testing a 1:7 complete A/C powered WT model. The A/C Simulation Models (GRASMs) for the assessment of environmental targets achievement in terms of air pollutants emission (CO₂ & NO_x) and external noise reduction, based on experimental results and enclosing the MTM Technologies, will be delivered to the Technology Evaluator.

Major milestones planned for 2015:

- Completion Ground Full Scale Test;
- WTT Demo Large Scale 90 Pax;
- E-ECS verification of integration on A/C on ground;
- Completion of Flight Test Demonstration;
- E-ECS for Regional A/C Completion Demonstration;
- Completion of Flight Simulator Demonstration;
- WTT Demo Large Scale 130 Pax;

Major deliverables planned for 2015:

- Fuselage Ground Test Demonstration results;
- Wing Box Ground Test Demonstration results;
- Cockpit Ground Test Demonstration results;
- Test Set-Up & FCS-EMA Delivery for Aircraft Flight Demo;
- Test Set-Up & LGS-EMA Delivery for Aircraft Flight Demo;
- E-ECS rack available;
- Systems FTI kit available;
- Flight test Engineering Station available;
- ATR (MSN098) modified A/C;
- Wind Tunnel demonstrators for 130-seat and 90-seat green regional A/C performances as above outlined and relevant tests results;

- Ground demonstrators of morphing flap and of LC&A system architecture and relevant tests results;
- Final MTM Report based on Simulation Test execution;
- GRASM (TP90 pax and GTF 130 pax A/C of Design Loop 3 and with MTM Technologies).

Main events:

- Static and Fatigue Full Scale Ground Demonstrators;
- WTT Demo Large Scale 90 & 130 Pax;
- Flight Test on ATR MSN 098;
- Demonstration of the Green FMS by a Regional Flight Simulator;
- GRA Annual Review Meeting (ARM).

3.3. GRC – Green Rotorcraft

The Green Rotorcraft ITD gathers and structures all activities concerning the integration of technologies and the demonstration on rotorcraft platforms, supported by activities performed within the Eco-Design ITD, the Sustainable and Green Engines ITD, the Systems for Green Operations ITD and the Technology Evaluator. It combines seven domains aiming at reducing the environmental footprint by reducing emissions and halving perceived noise for the next helicopter generation.

The main activities for the seven domains of the GRC ITD are:

GRC1 - Innovative rotor blades activities will be related to the design, manufacturing and testing of new blade devices including both active and passive systems, and the methodology and tools necessary to carry out parametric study for global rotor benefits. A flight test campaign is planned for the active Gurney flap rotor in 2015. In case additional funding can be made available a flight test campaign of a passively optimised rotor will be performed in early 2016

GRC2 - Reduced drag of airframe and dynamic systems activities will be related to the design of optimised shape, the manufacturing and testing of helicopter sub-parts such as the air inlet and engine exhaust, the rotor hub cap and fuselage aft body for several rotorcraft configurations including the tilt-rotor. Passive shape optimisation approach and vortex generators will be complemented with active control systems. Flight test campaigns starting in late 2014 and 2015 for testing integrated technologies.

GRC3 - Integration of innovative electrical systems activities will be focused on new architectures for more electrical helicopters including new technologies such as electric tail rotor, brushless starter generator, electro-mechanical actuators, electric taxiing, electric regenerative rotor brake and the management of energy recovery. Performance assessment of the different electrical architectures in a representative environment performed in 2014 and 2015 using the Copper Bird Test Rig.

GRC4 - Installation of a High compression engine on a light helicopter will consist in the development of a specific High compression engine power pack demonstrator to be installed on a modified EC-120 helicopter. Important milestones test are expected in 2014 with ground tests of the High compression engine powered helicopter. In case additional funding can be made available a flight test campaign will conclude the work in late 2014.

GRC5 - Environment-friendly flight paths activities will focus on the optimisation of the helicopter flight path relying both on new procedures in take-off and landing phase (IFR based) and new flight envelope definition to reduce noise (steep approach) and pollutant emissions. An intensive work with SESAR (Single European Sky Air Traffic Management Research), EASA (European Aviation Safety Agency) and ICAO (International Civil Aviation Organization) is planned to introduce new solutions operational by 2020. Flight tests are planned in 2014 and 2015.

GRC6 - EcoDesign Rotorcraft Demonstrators activities will be related to manufacturing and testing helicopter sub-assemblies such as a double-curved fairing, a tail unit section, an intermediate gear box, a main helicopter mast and a tail gear box. Implementation of new

eco-friendly materials and processes (thermoplastic composites, metallic alloys with “green” surface protection) based on results from the EcoDesign ITD and earlier projects.

GRC7 - Technology Evaluator for Rotorcraft activities are related to the packaging of results obtained for the different rotorcraft subsystems and the delivery of consistent behavioural models representing the future helicopter fleet for the Technology Evaluator to assess their environmental impact as compared to the fleet operated in 2000. Six behavioural models will be delivered from 2013 to 2015.

Year 2014

Overview

Most of the activities on GRC1 Innovative Rotor Blades sub-project will focus on the development of active and passive technologies. In particular, GRC1 objective can be broken down as follows:

- Assess the potential of active/passive rotor technologies to achieve a commercially viable solution enabling reduced rotor power consumption and reduced rotor acoustic signature. Targeted achievements shall be measured relative to fleet 2000 reference helicopters (see GRC7).
- Pursue development of the active twist concept from Friendcopter.
- Carry out parametric study and optimisation of active and passive blade lay-out for global rotor benefits.
- Develop methods necessary for the optimisation of blade design, actuation system integration, sensory data transmission, power transfer and control algorithms.
- Develop suitable open-loop and closed-loop control algorithms to manage the active system behaviour.

GRC2 activities will focus on the reduction of the helicopter and tilt-rotor overall drag by non-degrading its lift and handling quality, and by decreasing engine installation losses. Drag reduction of the tilt-rotor fuselage and lift over drag increase of its wing and empennages will be investigated and tested in wind tunnel and/or flight. Moreover, efficiency improvement (i.e. decrease pressure losses and distortions), noise emission reduction of engine intake, efficiency improvement (i.e. pressure recovery), increase of secondary mass flow and of engine exhaust will be addressed numerically in wind tunnel and/or in flight.

The GRC3 objective of Innovative Electrical Systems domain is the development of electrically-powered systems to replace hydraulic systems on rotorcraft and the reduction of carbon emissions by improved overall electrical power system energy efficiency. The objective can be broken down as follows:

- Assess the potential for electrical technologies to achieve a commercially viable solution that enables removal of hydraulic systems, improved electrical systems functionality, and reduced power consumption. The targeted achievements shall be measured relative to existing technologies, and the Reference Helicopters as defined by GRC7.
- Pursue model development of the electrical concepts.
- Carry out benefit analysis studies and optimisation of individual and collective technologies to provide electrical systems benefits.

- Definition and provision of technology prototypes, facilitating practical demonstration.
- Incorporation of prototypes into the Copper Bird, system test bench, or test airframe to demonstrate system behaviour and benefits.
- Optimisation of existing tasks to provide technology confidence at the highest Technology Readiness Level (TRL) demonstration possible.

GRC4 will focus on turbocharged High compression engine technology, developed in the automotive industry, with the objective to integrate this technology on helicopters to drastically reduce gas emission level (forecast: CO₂ more than 40%, NO_x more than 53%). Most of the activities will concern the integration of a flight worthy helicopter demonstrator based on the adaptation of an aeronautical high compression engine to helicopter specifications and the transformation of a turbine powered light helicopter.

The GRC5 objective is to reduce, for helicopter and tiltrotor aircraft, noise and polluting emissions through the optimisation of flight paths and, in addition, to develop new low-noise procedures to minimise noise perceived on ground during departure, low level flight and approach.

The GRC5 sub-project is aimed to develop:

- tools to optimise trajectories for low-noise and low-emissions
- a process to promulgate noise abatement procedures
- software to plan environmentally friendly mission profiles
- airborne hardware, and software, to allow flight crew to fly the low-noise and low-emission trajectories.

The general objective of GRC6 is to demonstrate eco-friendly life cycle processes in the phases of manufacturing, maintenance and disposal for specific helicopter components. The WP will demonstrate the possibility to eliminate substances considered hazardous. Activities will focus on the following demonstrators:

- Composite based structures/ Crosstube Fairing: the aim is to design and manufacture a typical rotorcraft cowling/fairing geometry using ecologic (‘green’) materials and processes to achieve a cost & weight saving compared to today’s solutions. The selection of the demonstrator geometry shall represent typical design details the process technology has to master.
- Composite based airframe structures/ Structural parts: the aim is to design and manufacture a composite primary (load-carrying) structural element out of ecologic materials.
- Metallic based transmission structures/ Transmission parts: the aim is to design and manufacture a demonstrative main helicopter mast and tail gear box.
- Metallic based transmission structures/ Gear box: this demonstrator will address the build of a REACH compliant and ECO efficient Intermediate Gear Box (IGB) and associated shaft.

Subproject GRC7 is the interface between the GRC-ITD and the Technology Evaluator (TE). GRC7 in its support to the TE will endeavour to ensure that the uniqueness of rotorcraft

operations in relation to fixed-wing aircraft is duly taken into account. GRC7 ultimately provides a rotorcraft assessment software platform called Phoenix to be integrated in the TE simulation framework to allow the TE to evaluate the possible environmental benefits of GRC sub-project technologies. The Phoenix platform will need to be refined and updated given the nature innovative of the developed technologies.. Therefore the iterative cycle of evolution of the platform will be continued, which is to be supported by the interaction between GRC7 and the other GRC sub-projects and the TE as the Technology Readiness Level (TRL) evolves.

Major milestones planned for 2014:

- Test Specimen Ready
- Flight Tests completed
- Critical Design Review (CDR) of the new air intake for the ECg light H/C.
- Wind tunnel tests of AW Heavy helicopter model for rotor hub tests
- Energy Recovery delivery to Copper Bird
- Ground test results
- H/C eco-VFR procedure implementation on full-scale realistic problems
- Eco-Flight Planner Final Demonstration
- Static Test
- Integration of Phoenix Black Box V5.1 in TE Platform SEL U1 + DEL (TEL U1, TEH, TEM)

Major deliverables planned for 2014:

- Test Specimen
- Prepreg model scale rotor blades
- Wireless power and data transfer interface for rotating frame
- RTM model scale rotor blade
- Report on active blades whirl tower test
- Summary of the Wind Tunnel test measurement results on AW heavy helicopter rotor head
- Synthesis report on WT measurements on a AW Heavy helicopter fuselage
- Data analysis and synthesis of wind tunnel measurements about air intakes of a tilt-rotor.
- GRC3.4.1 final report
- Updated Consumer Systems models (2014)
- Electrical tail rotor integration definition
- Interface document for Energy Recovery: final issue
- Iron bird test report
- Ground test report
- Final definition of the ideal High compression engine helicopter
- PITL verification results of T/R eco-VFR procedures
- Demonstration flight test proposal
- AW139 demonstration of low-noise IFR routes: test report

- AW139 demonstration of low-noise IFR procedures: test proposal
- AW139 demonstration of low-noise IFR procedures: test report
- TRAVEL D4.1: ATC/TR simulation: first experiment and shakedown
- Pilot-in-the-loop test of helicopter FMS with run-time low-noise planning: test report
- Flight test campaign on EC135-ACT/FHS (DLR)
- Report on Cross Tube Fairing Demonstrator manufacturing and analysis/evaluation
- LCA Data
- Phoenix Black Box V5.1 for TE–SELU1+DEL
- Single Engine Light Helicopter Models – EUROPA, TM Engine and HELENA V5.1
- Twin Engine Light Helicopter Models – EUROPA, TM Engine and HELENA
- High compression Single Engine Generic Helicopter Models – EUROPA, TM Engine and HELENA V5.1

Main events:

- 4th Assessment TE simulation framework results with updated PhoeniX.

Year 2015

Overview

Forecast and remaining activities planned from 2015 onwards for the seven domains are:

Innovative rotor blades activities will be related to the design, manufacturing and testing of new blade devices including both active and passive systems, and the methodology and tools necessary to carry out parametric study for global rotor benefits. The integration of the active gurney flap system in the rotor blade will be finished in 2015. The active twist concept will be further developed, which means in detail the manufacturing of the specimen and the bench testing in 2014 and the final test report in 2015. The passive blade design will be finished by the CDR in 2015, followed by manufacturing and whirl tower testing. This means demonstration on a whirl tower will be performed in 2015 for two rotor systems: one with active Gurney flap, the other with shape optimised blades. The whirl tower testing of the AGF rotor will be followed by a flight test campaign.

Reduced drag of airframe and dynamic systems activities will be related to the design of optimised shape, the manufacturing and testing of helicopter sub-parts such as the air inlet and engine exhaust, the rotor hub cap and fuselage aft body for several rotorcraft configurations including the tilt-rotor. Passive shape optimisation approach and vortex generators will be complemented with active control systems such as synthetic jets, pulse jets and continuous blowing. Wind tunnel campaigns will validate performance predictions all along the programme. Flight test campaigns will be performed in 2015 for testing integrated technologies.

Integration of innovative electrical systems activities will be focused on new architectures for more electrical helicopters including new technologies such as electric tail rotor, brushless starter generator, electro-mechanical actuators, electric taxiing, electric regenerative rotor brake and the management of energy recovery. Performance assessment of the different electrical architectures will keep being tested in a representative environment in 2015 using

the Copper Bird Test Rig along with various equipment tests to be performed on specific test benches from 2014 onwards. The electric tail rotor technology will be tested on a AW in-house test rig.

Environment-friendly flight paths activities will be related to the optimisation of the helicopter flight path relying both on new procedures in take-off and landing phase (IFR based) and new flight envelope definition to reduce noise (steep approach) and pollutant emissions. Along with the implementation of new devices in the flight management systems, an intensive work with SESAR (Single European Sky Air Traffic Management Research), EASA (European Aviation Safety Agency) and ICAO (International Civil Aviation Organization) is planned to make those new solutions operational by 2020. Flight tests are planned in 2015 to assess the benefits of new procedures in an operational environment.

The demonstration of integration of a *High compression Engine* on a Light Helicopter will be completed with the demonstrator ground tests by end 2014 and consequently, no further activity is currently planned during 2015 unless a decision to carry on with a flight demonstration is taken during 2014 by the JU.

EcoDesign Rotorcraft Demonstrators activities will be related to manufacturing and testing helicopter sub-assemblies such a tail unit section, an intermediate gear box, a main helicopter mast and a tail gear box. New eco-friendly materials and processes (thermoplastic composites, metallic alloys with “green” surface protection) based on results from the EcoDesign ITD and earlier projects will be implemented on these demonstrators and evaluated. Overall assessment of benefits for the whole life cycle will continue in 2015.

Technology Evaluator for Rotorcraft activities are related to the packaging of results obtained for the different rotorcraft subsystems and the delivery of consistent behavioural models representing the future helicopter fleet for the Technology Evaluator to assess their environmental impact as compared to the fleet operated in 2000. The delivery of the six behavioural models will be completed in 2015 including updates of those already delivered.

Major milestones planned for 2015:

- Wind tunnel tests of AW Light helicopter model for rotor hub tests
- Flight Tests of ECg light H/C with the new air intake
- Wind-tunnel test of the optimised GRC2 common platform
- Synthesis report on WT measurement on the ERICA tiltrotor fuselage model
- ETB Test
- HEMAS system and its adaptation kit delivery to Copper Bird
- T/R eco-IFR procedures validated by PITL simulations in laboratory environment (with ATC).
- Realisation of in-flight demonstrations
- Final flight test demonstration of Low-Noise VFR Approach Guidance on EC145
- Flight test with EC135-ACT/FHS
- In-flight validation of experimental FMS in operational environment
- Delivery of Final Phoenix platform to the TE

Major deliverables planned for 2015:

- Test report on wind tunnel experimental campaign of oscillating AGF airfoil in dynamic stall conditions
- Tooling ready for manufacturing
- Analysis 3D model rotor wind tunnel test
- Assessment of GRC1 Technology Benefits (all GRC1 partners) 2015
- Whirl Tower Test Report
- Summary of the Wind Tunnel test measurement results on AW light helicopter rotor head
- Summary on the flight test results for the ECg light helicopter featuring the new rotor head and fuselage fairings.
- Summary on the flight test results for the ECg medium helicopter featuring the new rotor head and fuselage fairings.
- Synthesis report on wind tunnel measurement on a fuselage featuring a ramp/hatch geometry with active devices
- Synthesis report on WT measurement on the ERICA tiltrotor fuselage model
- Synthesis report on the design and project study of tiltrotor fuselage in support of weight and performance.
- Synthesis report on the design of the air-Intake and exhaust of a tilt-rotor
- Synthesis Report of the Design Studies for an Optimised Green Tiltrotor
- Final report
- GRC3.4.6 final report
- HEMAS Final Report
- Final test plan for HEMASM21
- Final demonstration report
- TRAVEL D5.3: Final report
- Synthesis report of flight demonstration at Toulouse-Blagnac
- Synthesis report of flight demonstration at Seo de Urgel
- Eco-Flight Planner Final Demonstration report. (AWS)
- Flight Test Report on VFR Approach Guidance for EC145 (ECD)
- Flight Test evaluation of experimental FMS
- Phoenix Black Box V6.1 for TE – TEH U1
- Phoenix Black Box V7.1 for TE – TEL U2
- Light Twin Engine Helicopter Models – EUROPA, TM Engine and HELENA V7.1
- Heavy Twin Engine Helicopter Models – EUROPA, TM Engine and HELENA V6.1

Main events:

- M23 - Final TE Assessment results using final updated Phoenix simulation.

3.4. SAGE – Sustainable and Green Engines

2014 will be a key year for SAGE ITD. Most of the remaining design activities will be completed transforming the last concepts into freeze definitions. New engine tests will be launched and the ones started in 2013 will be finalized. These efforts will raise the Technology Readiness Level of sub-systems towards the overall whole engine system reaching TRL level 6. During this period another ramp-up in the spend will happen due to the costly detailed design activities, the manufacturing and the ground and flight tests of the demonstrators. This is reflected in the budgets for this period which demonstrates the high levels of budgets planned in 2014. In 2013, the Turboshift engine demonstrator will have been delivered and during 2014 – 2016, 4 more engine demonstrators will be delivered representing new technologies such as Open Rotor, Large 3 Shaft Turbofan, Geared Turbofan and Lean Burn.

Activities plan for year 2014

Overview

SAGE1 - Activities were reviewed after the Go decision made in 2013. The outcome was to reduce the activities further and support the work breakdown structure shown in figure 1.

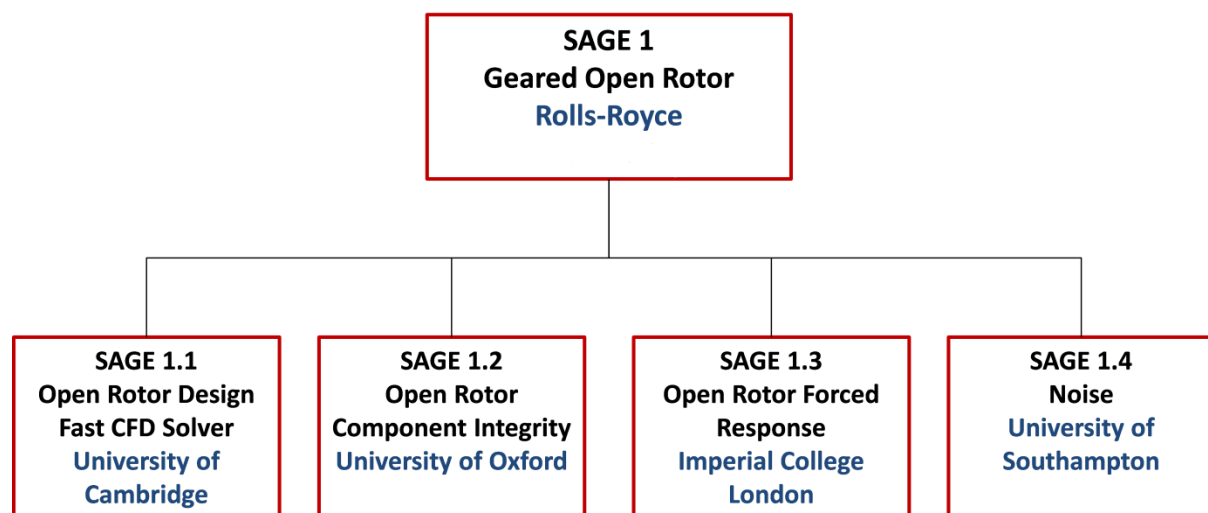


Figure 1: New SAGE 1 Work Breakdown Structure.

Therefore, SAGE 1 will now focus on 4 themes: Open Rotor (OR) Design Fast CFD; Component Integrity; Forced Response and Noise. These activities will cover develop the code to provide a fast capability to analyse and understand the steady and unsteady aerodynamics of installed open rotors, also leading to an enhanced understanding of the resultant aerodynamics, the project will develop the capability for impact engineering with composite materials for open rotor open rotor designs feature variable blade pitch angles in conjunction with an overhung rotor and the continuation of Aero and Noise Methodology Development.

SAGE 2 - The objectives of the Geared Open Rotor Demonstrator projects are to demonstrate technologies that contribute to assess open rotor architecture feasibility and environmental benefits, to adapt an existing gas generator and a rig for technology validation and integration demonstration, to develop enabling manufacturing technologies and materials where these are necessary to deliver the engine technologies for demonstration, to deliver and start to ground test a demonstrator in Q4 2015 and, on the basis of prediction and test data obtained from the engine, to assess the improvements in gaseous and noise emissions that may result from a production open rotor propulsion system. After the Preliminary Design Review in Q4 2013, 2014 will be the year of the freeze of the whole demonstrator definition with the completion of the CDR.

SAGE 3 - The Large 3 Shaft Engine project will demonstrate technologies applicable to large 3-shaft turbofan engines in the 60-95,000 lb thrust class, as concerns low pressure system. The project aim is to deliver TRL6 for these sub-systems through appropriate testing delivering engine conditions representative of potential future engine applications. Demonstration by rig testing will have completed in 2013 and the focus in 2014 will be on full-scale engine tests of the Composite Fan System and Low Pressure Turbine. Three engine tests are planned to be launched in 2014: flight test of the composite fan blades, ground test of the full composite fan system and ground test of the low pressure turbine. Additionally, the ground testing of the composite fan blades launched in 2013 will be completed.

SAGE 4 - The purpose of the advanced Geared Turbofan (GTF) Engine Demonstrator, as an important part of SAGE platform, is to improve necessary technologies in order to further reduce fuel burn / CO₂ by addressing efficiency and weight, to continue efforts to further decrease already low noise emission levels and to enhance reliability and cost. Main focus in 2014 will be manufacture, procurement and instrumentation work of modules and components, module level assembly work and test preparation for a successful test campaign in Q2-2015.

SAGE 5 - The Turboshift engine Demonstrator shall provide with the necessary technologies for the development of a new engine family equipping helicopter classes with a take-off weight from 3 tons (single-engine) to 6 tons (twin-engine), delivering TRL6 for the sub-systems studied and design in SAGE 5 through appropriate testing, delivering engine conditions representative of potential future engine applications. The technologies to be demonstrated will deliver improved specific fuel consumptions, noise and emissions in-line with the goals of the Clean Sky programme. Further Turboshift Demonstrator engine tests are scheduled in 2014 to demonstrate the innovative technologies related to the performance and thermo-mechanical behaviour.

SAGE 6 - The Lean Burn Project, started in 2011, consists of two major work streams. The first will define sub-system designs and associated verification strategies for concepts identified as most suitable for introduction into future gas turbine products. The second will focus on design and make activity to create a set of functionally representative experimental subsystems that can be integrated into a demonstration platform. It is anticipated that this

hardware will be subjected to both rig testing (2013 onwards), and engine testing (2015 – 2016).

Major milestones planned for 2014:

- Physical Design
- Achieve next loop of test data evaluation from on-going data evaluations
- Update of on-going far and near field noise predictions
- Update of associated transpositions to flight
- Further improved design, aero and prediction methods and tools
- CROR blade mechanical design methods and tool progress
- CROR blade manufacturability progress
- Definition of next generation RR CROR blades for Z49P2 testing projected for 2014
- Summary from on-going concept evaluations and according technology evaluations
- Design and manufacture of blades for tests TBC
- Other milestones TBD subject to outcome of AI/ SFWA GoNoGo decision intended mid-2013.
- Launch of manufacturing. *Even if the manufacturing of most parts will start after the completion of the CDR, long lead-time items procurement will be anticipated and will thus start in February 2014.*
- Critical Design Review (CDR). Freeze demonstrator definition
- Composite Fan Blade Ground test completion. Completion of the ALPS CFS1 ground engine demonstration of the composite fan blades
- Composite Fan Blade Flight Test Pass to Test. First flight test of the ALPS FTB1 composite fan blade demonstrator.
- Low Pressure Turbine Demonstrator Pass to Test. Pass to Test of ALPS LPT1 build for ground demonstration of low pressure turbine technologies
- Low Pressure Turbine Demonstrator Pass to Test. Pass to Test of ALPS LPT1 build for ground demonstration of low pressure turbine technologies
- System Level Test Readiness Review
- Engine Built 2 Endurance
- Engine Built 2 Performance Test The target is to validate the thermo-mechanical behaviour of the engine in very hot environment and verify the global performances of the innovative technologies implemented on the engine at high Turbine Entry Temperature
- Lean burn core engine demonstrator EFE Build 4 commissioning
- Critical Design Review (CDR), freeze of engine configuration
- Build start of ground test engine

Major deliverables planned for 2014:

- Test data evaluation reports from on-going data evaluations
- Summary from on-going far and near field noise predictions
- Associated transpositions to flight
- Summary regarding improved design, aero and prediction methods and tools

- CROR blade mechanical design methods and tool progress report
- CROR blade manufacturability progress report
- Summary of definition of next generation RR CROR blades for Z49P2 testing projected for 2015
- Summary from on-going concept evaluations and according technology evaluations
- Design and manufacture of blades for tests TBC
- Critical Design Review (CDR) closure report
- Freeze demonstrator definition
- First LLTI forging parts delivered
- Final Parts to Stores for Composite Fancase demonstration. Delivery of final parts for build of the ALPS CFS2 engine
- Final Parts to Stores for Composite Fancase demonstration. Delivery of final parts for build of the ALPS CFS2 engine
- Composite Fan Blade Ground Test Reports. Delivery of post-test reports closing out the ALPS CFS1 composite fan ground test campaign
- Final Parts on Stores
- Completed module and components instrumentation
- Turboshaft Demonstration. Engine demonstration of the innovative technologies in order to demonstrate performance and thermo-mechanical behaviour
- Critical Design Review (CDR) report for the ground test engine
- Delivery of finished parts to stores for ground test engine

Work plan for year 2015

Overview

2015 will be another key year for delivering engine demonstrators for the success of SAGE ITD. Additionally, SAGE 3 and SAGE 5 will be finalising their analysis of demonstrators performed during 2014. For SAGE 2, 4 and 6 there will be their first engine runs. These efforts will raise the Technology Readiness Level of sub-systems towards the overall whole engine system reaching TRL level 6. During this period the spend level will remain high during this intense period of demonstrator testing. This is reflected in the budgets for this period which demonstrates the high levels of budgets planned in 2015. In 2014, the large 3-shaft engine demonstrator, SAGE 3, will have been delivered with 3 more engine demonstrators being delivered in 2015 representing TRL increases in Open Rotor, Geared Turbofan and Lean Burn.

SAGE 1 will continue to focus on 4 themes: Open Rotor (OR) Design Fast CFD; Component Integrity; Forced Response and Noise. These activities will cover develop the code to provide a fast capability to analyse and understand the steady and unsteady aerodynamics of installed open rotors, also leading to an enhanced understanding of the resultant aerodynamics, the project will develop the capability for impact engineering with composite materials for open

rotor open rotor designs feature variable blade pitch angles in conjunction with an overhung rotor and the continuation of Aero and Noise Methodology Development.

SAGE 2 - The Geared Open Rotor Demonstrator project objectives are to demonstrate technologies that contribute to assess open rotor architecture feasibility and environmental benefits, to adapt an existing gas generator and a rig for technology validation and integration demonstration, to develop enabling manufacturing technologies and materials where these are necessary to deliver the engine technologies for demonstration, to deliver and install a demonstrator at the ground test facility in Q4 2015 and, on the basis of prediction and test data obtained from the engine, to assess the improvements in gaseous and noise emissions that may result from a production open rotor propulsion system. After the Critical Design Review in 2014, 2015 will be the year of the receipt of the parts, the assembly and instrumentation and the delivery of the SAGE2 demonstrator to the ground test facility.

SAGE 3 - The Large 3 Shaft Engine project will have been delivered in 2014 demonstrating technologies applicable to large 3-shaft turbofan engines in the 60-95,000 lb thrust class, as concerns low pressure system. The project aim will have delivered the TRL6 for these sub-systems through appropriate testing delivering engine conditions representative of potential future engine applications. Demonstration by rig testing will continue for the Low Pressure Turbine development.

SAGE 4 - The purpose of the advanced Geared Turbofan (GTF) Engine Demonstrator as an important part of SAGE platform is to further improve engine technologies in support of the everlasting reduction of fuel burn / CO₂ by addressing efficiency and weight and to continue efforts to further decrease already low noise emission levels as well as to enhance reliability and cost. After completing engine assembly and test preparation main focus in 2015 will be on full-scale engine demonstration of the Geared Turbofan in order to validate the selected technologies. After testing, the demonstrator engine will be taken off the test stand, disassembled and inspections will take place on module and component levels, followed by test analysis and reporting including the results of assessments of inserted technologies.

SAGE 5 - The Turboshaft engine Demonstrator shall provide with the necessary technologies for the development of a new engine family equipping helicopter classes with a take-off weight from 3 tons (single-engine) to 6 tons (twin-engine), delivering TRL6 for the sub-systems studied and design in SAGE 5 through appropriate testing, delivering engine conditions representative of potential future engine applications. The technologies to be demonstrated will deliver improved specific fuel consumptions, noise and emissions in-line with the goals of the Clean Sky programme. The main activity in 2015 for SAGE 5 will be the finalisation of the analysis of demonstrator test performed during 2014.

SAGE 6 - The Lean Burn Project, started in 2011, consists of two major work streams. The first will define sub-system designs and associated verification strategies for concepts identified as most suitable for introduction into future gas turbine products. The second will focus on design and make activity to create a set of functionally representative experimental subsystems that can be integrated into a demonstration platform. It is anticipated that this

hardware will be subjected to both rig testing (2013 onwards), and engine testing (2015 – 2016).

Major milestones planned for 2015:

- Open Rotor Component Integrity (Composite damage model available);
- Open Rotor Forced Response (Technical Report);
- Open Rotor Component Integrity;
- Open Rotor Forced Response;
- Start of the assembly of the demonstrator;
- Installation of the GTD on the ground test facility;
- GTF Demonstrator on test stand. *Final test preparation at test cell to allow full-scale GTF engine demonstration;*
- GTF Demonstrators DR6. *Verifying demonstrator test results with objectives;*
- Finalisation of results analysis of demonstrators performed during 2014;
- First Engine Run.

Major deliverables planned for 2015:

- Open Rotor Design Fast CFD Solver (Update Report);
- Open Rotor Component Integrity (Update Report);
- Open Rotor Forced Response (Update Report);
- Noise (Update Report) ;
- Mounts test report;
- Demonstrator ready for test;
- GTF demonstrator ground test report. *Delivery of post-test reports;*
- Finalisation of results analysis of demonstrators performed during 2014;
- Engine ready to test.

3.5. SGO – Systems for Green Operations

The “Systems for Green Operations” ITD is focused on the development and demonstration of innovative technologies for *Management of Aircraft Energy*, dealing with electrical systems for fixed and rotary wing aircraft, and *Management of Trajectory and Mission*, addressing the optimisation of all flight phases from an environmental point of view.

Year 2014

Overview

Building on developments in the previous years of Clean Sky, SGO work will reach high TRLs (4 to 6 depending on the technology threads) in 2014. Many of these high TRLs will be obtained through high-fidelity ground- demonstrations or in flight tests, in collaboration with vehicle ITDs: Smart Fixed Wing Aircraft, Green Regional Aircraft and Green Rotorcraft. Thus, the SGO ITD will deliver large-scale ground-based architectural integration of electrical technologies comprising generation of electricity, distribution and electrical loads, together with their management. The demonstration of these integrated systems will be done in Airbus PROVEN test bench in 2014, early 2015 and will achieve up to TRL5 for the sub-systems.

In the field of electrical systems, including environmental conditioning, thermal management, electrical power generation and conversion, ice protection, major milestones will be reached in 2014:

- An innovative Ice detection system has reached TRL4 in 2013 and will be developed further during 2014 followed by the TRL5 review early 2015.
- Wing Ice protection systems have reached TRL4 in 2013 and enhanced prototypes will be delivered to the PROVEN test bench for ground validation starting end 2014, in order to prepare TRL5 gate early 2015.
- The maturity of the electrical environmental control system will also be enhanced during 2014, with two main streams contributing to the development: on-ground validation of the 70kW turbomachines with performance tests in altitude chamber on one hand. On the other hand – a reduced scale pack (50kW) will be designed and manufactured for integration in an A320 test aircraft, to evaluate the functional behaviour of the system during flight tests end 2015/beginning 2016.
- Another electrical ECS demonstrator for the Regional Aircraft application will be developed throughout 2014 reaching TRL4 end of the year.
- Flight proven technologies and sub-systems for thermal exchange and management, including liquid loops and large skin heat exchanger.
- The flight test campaign on the skin heat exchanger is scheduled mid-2014 to reach TRL6 end 2014.
- An innovative electrical power distribution centre will be completed early 2014 by using different equipment developed in SGO i.e. power modules, cooling equipment and

switching components. The power centre will be delivered to PROVEN test rig and will achieve TRL5 in second half of 2014.

- An electrical synchronized actuation system for engine nacelle is under test and will reach TRL5 in second quarter of 2014.
- In the field of Thermal Load Management Function, the development in 2014 will lead to the delivery of a prototype by mid-2014 for integration in a system test rig.

SGO will also deliver a number of system prototypes and equipment to other ITDs in 2014, for tests to be carried out in 2014 and 2015:

- Power Generation and Conversion systems prototypes, adapted to the specifications of each platform will be delivered to Eco-design (Bizjet), GRA (regional aircraft) and helicopter (GRC) and will be integrated and tested in COPPER BIRD tests bench throughout 2014.
- An electrical ECS test bench will be delivered to COPPER Bird test rig for integration and test early 2014.
- Optimised trajectories for all flight phases, evaluated in representative conditions on simulators and integrated in existing Flight Management Systems for full automation – TRL5 for the first flight phases will be reached by end 2014, before final tests in 2015.
- Flight tests of a Flight Management function allowing continuous descent in time constrained environment will be prepared, with TRL5 reached by end 2014 after testing on GRACE flight simulator (Time and Energy Managed Operations – TEMO). The system should be ready for flight test early 2015.
- Integration of new weather radar algorithms and trajectory optimisation functions will be completed in 2014 and TRL4 will be achieved by the end of the year.
- Technologies for electrical taxi.
- The on-board wheel actuator system will be further developed to prepare full scale dynamometer tests early 2015. Developments on the dedicated autonomous towing vehicle have been completed in 2013, reaching TRL 6 by full scale demonstration with a large aircraft.

Major milestones planned for 2014:

- TRL5 Nacelle Actuation System
- TRL4 E-ECS for Regional A/C
- TRL4 50KW Power electronics for E- ECS for large Aircraft
- TRL5 for Electrical Power Distribution System
- TRL 5 and 6 Skin Heat Exchanger
- TRL6 Power module and converter design
- TRL5 Multi Criteria Departure function
- TRL5 Adaptive Increased Glideslope function
- TRL5 Time and Energy Managed Operations in descent function

Major deliverables planned for 2014:

- Prototype skin heat exchanger subsystem for flight tests
- Tested Power Electronic Module for Generic test bench

- Tested high-speed permanent magnet generator and its associated PEM for Generic test bench
- Hardware to demonstrate Power Electronic Module and converter technology
- Virtual test results for ground test campaign (G1)
- Electrical Nacelle Actuation System - Final test report
- Validated Flight Test results for F.4 (Skin Heat Exchanger flight tests)
- Two tested generators, two associated GCUs and one BPCU for GRA flight tests
- HEMAS: Swashplate actuators for SGO internal validation tests
- Prototype of thermal management function
- WIPS for Business jet Icing wind tunnel test report
- Two tested high-low DC / DC voltage bi-way converter
- ECS Control laws configuration for Regional A/C Electrical Test Bench
- GATAC v3 Development and Validation Report
- Advanced Weather Radar algorithms and trajectory optimisation agents Integration report
- Departure and Final Approach function FMS implementation report
- Final validation report on time-based operations using absolute spacing
- Smart Operation on ground development report

Year 2015

Overview

In early 2015 the large scale integration test of electrical systems will be completed on Airbus test bench. In addition to the completion of electrical system testing, in 2015 a thermal test rig will host thermal management hardware i.e. the VCS hardware and the thermal load management function.

Other major milestones will be reached in 2015:

- An innovative Ice detection system will reach TRL5 in 2015 and the flight test hardware will be delivered for flight test aircraft integration. The test campaign itself will take place in 2016.
- The same test campaign as for ice detection will include the wing ice protection systems which will reach the TRL5 gate early 2015, hardware for the flight tests being delivered end 2015.
- The maturity demonstration of the electrical environmental control system will be completed beginning of 2015. The e-ECS flight tests (reduced pack size of 50kW) will be performed in 2016.
- The electrical ECS demonstrator for the Regional Aircraft application will be developed throughout 2014 reaching TRL4 end of 2014. The flight test for this system is planned mid of 2015.
- Mid 2015, SGO will deliver the HEMAS hardware for the helicopter architecture, to be tested in cooperation with the GRC ITD on the COPPER Bird in the second half of 2015.
- In the field of FMS Optimised trajectories, the cruise function providing optimised steps in cruise, will achieve TRL5, with tests in simulated environment. In parallel, function

targeting the take-off and final approach phase will be assessed with the involvement of an airline. Finally, the 3 functions will be integrated in an FMS prototype to confirm industrial feasibility with final tests preparation in 2015 and finalization of the TRL6 activities in 2016.

- The Flight Management and guidance function will be finalised in 2015, with flight tests on board a Cessna Citation aircraft.
- The final tests of integrated new weather radar algorithms and trajectory optimisation functions on GRA regional aircraft simulator will be completed in 2015, providing technical results to achieve TRL5.
- Technologies for electrical taxi via an on-board wheel actuator system will be tested in a full scale dynamometer bench early 2015

Main results – validated during TRL gates - and expected gains will be passed to vehicle ITDs for further tests and/or integration in Concept Aircraft models, to be transferred to the Technology Evaluator for consolidation and full assessment of environmental gains obtained by Clean Sky research.

In the field of mission optimisation functions, further coordination with SESAR will be pursued, in order to ensure consistency of the Clean Sky functions with the future evolutions of the Air Traffic Management system.

Major milestones planned for 2015:

- TRL5 E-ECS for Regional A/C
- TRL4 ECS mid-size pack (large aircraft)
- TRL5 50KW Power electronics for E- ECS (large aircraft)
- TRL4 Helicopter electro-mechanical actuation system HEMAS
- TRL5 WIPS System - Electromechanical Deicing System
- TRL5 Vapour Cycle System
- TRL5 Primary in Flight Ice Detection System
- TRL5 On-board Optimisation (Q-AI)
- TRL5 Multi step Cruise function

Major deliverables planned for 2015:

- PFIDS Delivery for flight tests
- Vapour cycle system for thermal bench tests
- Scoop intake, process air channel and RAM channel incl. protection systems to large aircraft
- Mid-Size pack, pack controller, power electronics and associated cooling system to large aircraft
- ECS Release of Equipment for Flight Test Demonstrator in GRA
- Report on HEMAS final tests results
- Methods and Tools : Test and Verification final report
- Flight Test results for Time and Energy Management function (MPG-TEMO: Final report cycle 2)

- Final Test results of A-WxR and Q-AI ground test in Regional simulator
- Multi step cruise function FMS implementation report
- Smart Operation on ground System Ground test report

3.6. ECO – Eco Design

Eco-Design ITD is organized in the two major areas of EDA (Eco-Design for Airframe) and EDS [Eco-Design for Systems (small aircraft)].

The **EDA** part of the Eco-Design ITD is meant to tackle the environmental issues by focusing on the following challenges:

1. To identify and mature environmentally sound (“green”) materials and processes for a/c production.
2. To identify and mature environmentally sound (“green”) materials and processes for a/c maintenance and use processes.
3. To improve the field of end-of-life a/c operations after several decades of operation, including reuse, recyclability and disposal (“elimination”) issues.
4. To provide means for an eco-design process in order to minimize the overall environmental impact of a/c production, use/maintenance and disposal.

Year 2014

Overview

In 2014, the work to be performed in the frame of **EDA** will continue on the following Work Packages:

- WP A.2 Technology Development,
- WP A.3 Application Studies,
- WP A.5/A.6 Lifecycle Ground Demonstration.

In WP A.2, the work is dedicated to the maturation of the most innovative technologies selected at the end of 2010. The end of the development phase is beginning of October 2013 but remaining activities will be performed beginning of 2014 for the finalisation of CfP projects.

In WP A.3, WP A.3.1 (Eco-Statements) and A.3.2 (Extrapolation to Industrial Conditions) will be active:

- In WP A.3.1, after the finalisation of the development of evaluation tools (A.3.1.1) and of the eco-statement of current technologies (A.3.1.2), the work on 2014 will be devoted to the eco-statement of new technologies.
- In WP A.3.2, activities will continue on the extrapolation of the technologies developed in WP A.2 to industrial conditions. The WP should end mid of 2014.

After finalisation of WP A.4, WP A.5 will be active in the 1st quarter of 2014 and WP A.6 until end of 2015. Ground demonstration activities will be carried out for the equipment (A.6.2) as well as for the equipped airframe demonstrators (A.6.1).

The general objective the **EDS** part of the Eco-Design ITD is to gain a valuable and comprehensive insight into the concept of all-electric aircraft. It is expected that the use of electricity as the only energy medium, by removing the hydraulic fluid and by the use of on-board power-by-wire will offer significant benefits in terms of aircraft maintenance and disposal environmental impact, and will yield new possibilities in terms of energy

management (e.g.: intelligent load shedding, power regeneration on actuators, sharing of Electrical Control Unit over actuator).

The work to be performed in 2014 will consist in pursuing the common activities (WP S.1), performing the characterization of the business jet sub-systems architectures (WP S.2). On 2014, the preparation of the benches related activities (WP S.3 and WP S.4) will be finalised and the main activity will be the carrying out of the electrical and thermal tests (WP S.3.5 and S.4.5).

The WP S.1 common activities will continue in 2014 through WP S.1.6 (Models & Data), the last active WP in 2014.

The work within WP S.2 will continue throughout 2014 essentially at the level of the bizjet architecture trade-off (S.2.6) supported by modelling activities (S.2.5).

The WP S.3 (Electrical Test Bench) and S.4 (Thermal Test Bench) activities will continue in 2014. Beginning of 2014 will see the finalisation of the ETB (Electrical Test Bench) and TTB (Thermal Test Bench) integration and the electrical and thermal tests initiated in 2013 will continue during 2014.

The main technical deliverables to be produced in 2014 are set out in the following table.

Major milestones planned for 2014:

- End of technology development to TRL 5 (including GAPs)
- End of current eco-statement on reference parts
- End of final eco-statement on reference parts
- Technical and economical impacts review
- Eco-design guidelines deliverables
- Electrical Test Bench : 2nd Test Readiness Review (TRR)
- Electrical Test Bench: Generic configuration acceptance report
- End of Air Cooling Calorimeter integration
- End of Mock-Up integration
- General synthesis of WP S.1

Major deliverables planned for 2014:

- Eco-Design Guideline
- Eco-statement & eco-analysis on reference technologies: final report
- Equipped Airframe demonstration preparation: Synthesis Report
- Electrical Test Bench: Generic configuration acceptance report
- Report on integrated ACC
- General synthesis of WP S.1

Year 2015

Overview

Eco-Design ITD is organized in the two major areas of EDA (Eco-Design for Airframe) and EDS [Eco-Design for Systems (small aircraft)].

The **EDA** part of the Eco-Design ITD is meant to tackle the environmental issues by focusing on the following challenges:

1. To identify and mature environmentally sound (“green”) materials and processes for a/c production.
2. To identify and mature environmentally sound (“green”) materials and processes for a/c maintenance and use processes.
3. To improve the field of end-of-life a/c operations after several decades of operation, including reuse, recyclability and disposal (“elimination”) issues.
4. To provide means for an eco-design process in order to minimize the overall environmental impact of aircraft production, use/maintenance, and disposal. In 2015, the work to be performed in the frame of **EDA** will continue on the following Work Packages:

- WP A.3 Application Studies,
- WP A.6 Lifecycle Ground Demonstration.

In WP A.3, WP A.3.1.1 (Evaluation Tools), A.3.1.3 (Final Eco-Statement) will be active and the final synthesis will be produced.

- In WP A.3.1.1 the activity will focus on the finalisation of the database for the new technologies by using results from the ground demonstrations.
- In WP A.3.1.3, the work in 2015 will be devoted to the finalisation of eco-statement of new technologies.

Ground demonstration activities will be carried out and finalised for the equipment (A.6.2) as well as for the equipped airframe demonstrators (A.6.1).

The EDA part will be finalised by the end of 2015 to produce conclusion on new technologies (feasibility, interest and final TRL). Data will be provided to the TE for aircraft/mission level final assessment.

The work to be performed in 2015 in the frame of EDS part of the Eco-Design ITD will consist in pursuing and finalising the characterization of the business jet sub-systems architectures (WP S.2).

The work within WP S.2 will continue throughout 2015 essentially at the level of the bizjet architecture trade-off (S.2.6) supported by modelling activities (S.2.5) and ground tests results. In fact, in 2015, the ground electrical tests (WP S.3) and thermal tests (WP S.4) activities will be also finalised including results analysis and validation.

Major milestones planned for 2015:

- Final results of demonstrations to TRL 6 - Equipped airframe
- Final results of demonstrations to TRL 6 - Equipment
- General synthesis of WP S.2
- General synthesis of WP S.3
- General synthesis of WP S.4

Major deliverables planned for 2015:

- Dissemination & Communication Plan (update)
- Eco-Statement Final Report
- Equipped Airframe demonstration: Synthesis Report
- Airframe demonstrators: final results
- Equipment demonstrators Synthesis Report
- Application studies Final Synthesis Report
- Thermal bench conclusions and recommendations
- Final Review
- General synthesis of WP S.4
- General synthesis of WP S.2
- General synthesis of WP S.3

3.7. TE - Technology Evaluator

The TE will perform in 2014 a global environmental Clean Sky Assessment, based on its set of dedicated tools, in order to monitor the environmental progress brought by ITDs' technology outputs, and in order to ensure a consistent technical assessment approach with respect to the environmental objectives. This 2014 Assessment will consider all segments of commercial aviation, ranging from large and regional aircraft to helicopters and business jets. This environmental impact assessment will be done, as in the previous TE assessments, at three complementary levels:

- Mission level, considering one single aircraft flying a set of typical missions. For fixed-wing aircraft, missions are defined in terms of a set of representative ranges. In case of helicopters, typical missions will be specifically defined;
- Airport (operations) level, for instance around an airport, considering all departing and arriving flights on a single (representative) day
- Global air transport system level, considering the global aircraft and rotorcraft fleet.

The TE completed its first and second assessments beginning 2012 and 2013 respectively. A further assessment is underway for mid-2014. During the period 2015-2016, the TE will continue its Clean Sky technology evaluation task based on environmental metrics, in order to reach the contractual CS final assessment in 2016.

These global environmental assessments reflect the global status of the Clean Sky programme with respect to its environmental objectives. From the 2014 assessment, contrary to the previous ones which were performed on a yearly basis, they are now aligned with ITDs models updates planning.

These updates of the ITD a/c models result from the integration in these models of new and higher TRL level technologies. Also, from one assessment to another, more complex scenario will be considered (more airports, taking into account SESAR, updating forecasts). They will also aim at improving the TE processes and tools in order to create a user friendly toolset.

Yet, beside these global assessments, the TE will go on performing every year partial assessments and trade-off studies upon request of such or such ITDs.

All these global or partial assessments aim to help secure the final TE Assessment which is planned for the end of 2016, after the completion of the various ITDs' work programmes and demonstrations.

Global assessments planning

The TE completed its first and second assessments beginning 2012 and 2013 respectively. A further assessment is underway for mid-2014. During the period 2015-2016, the TE will continue its Clean Sky technology evaluation task based on environmental metrics, in order to reach the contractual CS final assessment in 2016.

All these global or partial assessments aim to help secure the final TE Assessment which is planned for the mid of 2016.

Detailed Scope of Work of Technology Evaluator

This work plan is based on results reached by the first and second global assessments, and is organized on the following basis:

- In June 2014 another global TE assessment will be produced.
- In 2015, either another global TE assessment or only partial TE assessments will be achieved, according to the status of the technology achievements and demonstrations in the ITDs
- In 2016, the final CS year, the final assessment will be produced.

This incremental way of working reduces the risk of both content and delay for the final 2016 assessment. It also allows the TE to benefit from the achievements of the partial assessments of the year before to improve the results of the year after.

Each year, the main outputs are:

- The issue of the global assessment report, in case such an assessment has been planned for the year (in June 2014, possibly in 2015, and final in 2016) ;
- The issue of the results of partial assessments of the year.

These outputs are strongly dependant on the inputs expected from the ITDs. These inputs are the updated ITDs a/c models and LCA data to be used in the TE global or partial assessments of the year. To avoid any delay in the issue of the assessment report by the TE, they must be received early enough before the issue by the TE of the global or partial assessment results (6 or 3 month, respectively).

In addition to these TE global or partial assessments, trade-off studies can be performed for the ITDs, on the basis of a compromise between their needs, and the available TE budget dedicated to this activity, knowing that the assessment task is a priority.

It is anticipated that these trade-off requests should increase with the time, when on the one hand, the TE system will be more complete, and on the other hand when the ITDs demonstrators will have reached a higher TRL level.

To support both assessments and trade-off studies, the TE system will be upgraded every year, following the same incremental procedure, on the basis of user's feedback, in order to get it both more powerful and easy to use.

Year 2014

Overview

Objective

To perform the 2014 global assessment which will include improved ITDs a/c models, updated airport, ATS scenario, and LCA scenario; trade-off studies and an updated TE system.

This objective is detailed by WP in the following:

WP1: Planning

- 2014 planning updates of the global and partial TE assessments as well as trade-off studies until 2016, taking into account the major ITDs demonstration and TRL achievements

WP2: models

- ITDs a/c models
- 2014 PANEM update (bizjet/mainliners): integration of new or updated functionalities as required
- 2014 GRASM update: integration of new or updated functionalities as required
- 2014 Phoenix update or release of: SEL/TEM/DEL models, including the integration of Turbomeca engine modules for SEL and TEM

WP3 : TE system

- Update TE computer system: TE-IS and 3 platforms simulation framework

WP4: TE assessments

- TE global assessment in June 2014, including PANEM, GRASM and PHOENIX models updates
- Mission level: Mission assessments defined begin 2014 including development/updates of ITD models
- Airport level: Airport assessments according to specification defined begin 2014 including updates of and new airports and updated ITD models
- ATS level: ATS assessments according to specification defined begin 2014 including updates of forecasts / traffic scenarios and updated ITD models
- LCA: Perform demonstration LCA for production phase for CleanSky reference aircraft/rotorcraft, definition of ground operations data

Major milestone planned for 2014

- End June 2014 : TE assessment report

Major deliverables planned for 2014

- Mid March : 2013 Annual report
- End June 2014 : TE assessment report

Year 2015

Overview

Objective: to perform the 2015 assessments which will include improved ITDs a/c models, updated airport, ATS scenario, and LCA scenario; trade-off studies and an updated TE system.

This objective is detailed by WP in the following:

WP1: Planning

- 2015 planning updates of the global and partial TE assessments as well as trade-off studies until 2016, taking into account the major ITDs demonstration and TRL achievements.

WP2: models

ITDs a/c models

- 2015 PANEM update (bizjet/mainliners): integration of new or updated functionalities as required, i.e. full SGO functionalities should be inserted into the PANEM mainliner model and an update of the HSBJ model made
- 2015 GRASM update: integration of new or updated functionalities as required (loop 3 and SGO functionalities)
- 2015 Phoenix update or release of: TEH, TEL models

WP3 : TE system

- Update TE computer system: TE-IS and 3 platforms simulation framework

WP4: TE assessments

TE partial or global assessment according to the availabilities of the PANEM, GRASM and PHOENIX models updates.

Mission level: Mission assessments defined begin 2015 including development/updates of ITD models.

Airport level: Airport assessments according to specification defined begin 2015 including updates of and new airports and updated ITD models.

ATS level: ATS assessments according to specification defined begin 2015 including updates of forecasts / traffic scenarios and updated ITD models and continuation of economic study activity.

LCA: Perform demonstration of LCA environmental improvement by comparing LCA for CleanSky reference and conceptual aircraft/rotorcraft.

Major milestones planned for 2015 :

- End Jan 2015 : TE assessments specifications
- End June 2015: 2015 TE assessment performance completed (partial or global according to Specifications)

Major deliverables planned for 2015:

- Mid-March 2015: 2014 annual report
- End June 2015: TE assessment reports (including JU Member Summary Report and Publishable Executive Summary)

4. CALL ACTIVITIES IN 2014-2015

Grant agreements for Partners (GAPs)

The evaluation results of the call 16 which took place in December 2013 enabled the JU to have a clear picture of the target to reach (the minimum 200 m € to be granted to partners arising from the calls process).

5. OBJECTIVES AND INDICATORS

As the Clean Sky programme approaches its final phase, the objectives covering the remaining period are shown below.

Objectives for 2014 to 2017

The overall objectives for this period are:

- To run all the demonstrators (ground or flight demonstrators)
- To achieve the environmental targets.

The two tables below give respectively the list of the demonstrators and the environmental forecasts:

DEMONSTRATORS

SFWA	High Speed Smart Wing Flight Demonstrator Airbus A340-300 flight test
	Advanced load control for Smart Wing - Ground test bed for large transport aircraft - Flight test for vibration control for bizjet
	Smart Wing High Lift Trailing Edge Device Full scale demonstrator, ground test only
	Innovative afterbody Full scale demonstrator, ground test only
	Innovative Empennage Demonstrator Full scale demonstrator, ground test only
GRA	Static & Fatigue Test Full Scale Ground Demonstration
	Large scale Wind Tunnel Test Demonstration - Acoustic & Aerodynamic WT Test - Turbo Prop 90 pax - NLF wing aerodynamic & aeroelastic design WT Tests - 130 - Geared Turbo Fan configuration
	Ground Laboratory Test (COPPER BIRD and other)
	Flight Simulator on ground Green FMS Final Demonstration on GRA Flight Simulator
	Integrated In-Flight DEMO ATR Integrated In-Flight Test - ATR 72 FTB
GRC	Innovative Rotor blades, passive and active (AGF), on Ground and in Flight
	Drag reduction on Ground / in Flight
	Medium helicopter electrical system demonstrator
	Lightweight helicopter electromechanical actuation
	Electric Tail Rotor Prototype
	Diesel powered flight worthy helicopter Demonstrator
	Flightpath operational Demonstrations
	Thermoplastic composite faring demonstrator

	Thermoplastic composite tailcone demonstrator
	Surface treatments for tail gearbox and rotor mast
	Surface treatments and welding technology for intermediate gearbox
	Thermoplastic composite drive shaft for intermediate gearbox
SGO	VIRTUAL IRON BIRD
	COPPER BIRD • Ground Test (Nacelle Actuation System, Power Generation and Conversion, Generators, Power Rectifiers, Electrical ECS Demonstrator, HEMAS)
	PROVEN (Ground test rig at Airbus Toulouse) • Flight Test (Environemental Control System Large Aircraft - Ice Protection and Ice Detection Systems) • Ground Tests (Power Generation and Conversion S/Gs, PEM - Eletrical Power Distribution System/Power Center)
	• Flight Tests (Thermal Management Skin Haet Exchanger) • Ground Tests (Thermal Management Vapour Cycle System inclucing Compressor)
	AIR LAB, MOSAR & GRACE simulations
	Electric systems integration • Ground Tests (Power Generation and Conversion EDS ITD)
SAGE	Geared Open Rotor • CROR Ground Test Demonstrator
	Advanced Low Pressure System (ALPS) Demonstrator
	Geared Turbofan Demonstrator • Ground Test - Engine demonstrator based on a GTF donor engine
	Large 3-shaft Turbofan • Ground tests Demonstrator (to study aero-performance, flutter, blade integrity and bird impact capability for the composite fan system and low pressure turbine). • Flight test Demonstrator (in-flight operability of the composite fan blades). • Outdoor ground testing (to determine composite fan system flutter behaviour under cross-wind conditions and noise performance. • Icing tests (to determine ice shedding behaviour of blades and impact damage tolerances of new liners).
	Lean Burn Demonstrator • Ground Test - Lean Burn Combustion System demonstrator engine
ECO	Electrical Ground Test (Copper Bird®) • High power, High Voltage Large electrical network for validation of the All Electrical Concept for small aircraft. It includes power generation, power distribution and consumers (actuators, ECS simulation, etc)
	Thermal Ground Test • Simulation of thermal exchanges of 3 sections of an aircraft in a representative environment. Main objective is the validation of the thermal modeling process of an overall aircraft.
	Clustered technologies airframe and equipment demonstrators • 12 demonstrators related to Airframe (e.g. Fuselage panel, Cabin furniture) • 6 Equipment demonstrators (e.g. Cables, connectors, part of air cooling unit)

Environmental forecasts

The following figures, summarized here for a limited number of air transport segments, are based on the initial estimates and have been refined during 2011-2012. For a clarification of the Concept Aircraft please refer to Appendix 2 of the Clean Sky Development Plan. The ranges of potential improvements result from the groupings of technologies which are expected to reach the maturity of a successful demonstration within the Programme timeframe. All environmental benefits are related to a Year 2000 reference.

Aircraft	CO₂ [%]	NO_x [%]	Noise area difference ratio at take-off (%)
Low Speed Bizjet	-30 to -40	-30 to -40	-60 to -70
Regional turboprop	-25 to -30	-25 to -30	-40 to -50
Short/ Medium Range / CROR	-25 to -35	-25 to -35	-30 to -40
Light twin engine rotorcraft	-15 to -30	-55 to -70	-40 to -50

Objectives for 2014

Clean Sky annual objectives are linked to the completion of the planned operational tasks, the progress towards the technologies readiness, the environmental benefits assessment, the control of expenditures, the satisfactory scheduling and outcome of calls for proposals and the further improvement of the JU's quality management and internal control system.

The following objectives are set for 2014. They are divided below as administrative objectives and operational objectives.

Operational Objectives:

- Smart Fixed Wing Aircraft Natural Laminar Flow “BLADE” wing demonstrator Critical Design Review performed
- Low Sweep Bizjet Vibration Control Ground Test, Critical Design Review performed
- Green Regional Aircraft Fuselage Barrel and Wing Box demonstrators finalized
- ATR72 Flying Test Bed, Flight Test Readiness Review performed
- Rotorcraft Active blades tested on ground (wind tunnel and whirl tower preparation)
- Rotorcraft Diesel engine tested on ground
- Open Rotor Ground Demonstrator Critical Design Review held
- Large 3-shaft engine Composite Fan Blade Ground test campaign performed
- Engine Build 2 Turboshaft Performance tests performed
- Power generation and electrical distribution systems tested on ground
- Green Flight Management System tested in simulator
- Thermal Test Bench tests for Eco Design performed
- Fully-fledged Technology Evaluator assessment available at mid-year.

Administrative Objectives:

- A reliable financial management and reporting to the JU's individual stakeholders is ensured, in order to maintain the confidence of the financing parties, i.e. the European Union and the industrial members and partners of CS;
- 90% of GAM cost claims received are formally dealt with (validated, put on hold or refused) before end of May each year;
- 40% of GAPs are formally closed by June 2015;
- The ex-post audits on FP7 projects are performed according to the plan and show a materiality of errors lower than 2 % for the total programme period. The ex-post audit strategy for H2020 projects is developed and responsibilities are allocated to the CAS and the JU.

The JU has implemented various tools to monitor the execution of the programme in terms of productivity, achievements, planning and risks of the operations.

Clean Sky Programme (FP7) Indicators

The following list of indicators was set up in 2011 and has been applicable since the beginning of 2012. These indicators allow the monitoring of the operational activities. The most important of these indicators are summarized below, in relation to the JU process concerned. They are assessed on an annual basis.

Indicator ID	Indicator short name	Description of the indicator	Target for 2014 % or nr.
Ind 1.9.2 A	Risk mitigation JU	Number of very important or critical risks on JU level without mitigation action (including also action defined but not implemented and unsuccessful actions)	0
Ind 1.9.2 B	Risk mitigation ITDs	Number of very important or critical risks on ITD level without mitigation action (including also actions defined but not implemented and unsuccessful actions)	0
Ind 2.5.6 A	Finalising of GAPS	Percentage of contracts signed in less than 8 months after the call closure	50%
Ind. 2.6 A	Deliverables of GAPS	Percentage of final reports due from partners on the schedule	80%
Ind. 2.7.1 A	AIP execution by members - resources	Percentage of resources consumption versus plan (members only)	90%
Ind 2.7.1 B	AIP execution by members - deliverables	Percentage of deliverables available versus plan (members only)	90%
Ind 2.9 C	Budget execution - payments operational	Percentage of payments made within the deadlines	85%
Ind 2.11 A	Dissemination of results	Number of publications from ITDs registered at JU level	3*ITD / 21
Ind 5.3 A	Ex-post audits - coverage	Percentage of operational expenses (incurred for FP7 projects) covered by ex-post audits	20%
Ind 5.3 D	Ex-post audits - error rates	Residual error rates resulting from audits at the beneficiaries per year and accumulated for the programme (FP7).	2%

Concerning the monitoring of the activity of the Members within the ITDs, which is the major part of the operations, the following tools are maintained:

- Internal rules to set the Grant Agreements Annex 1B, including technical risks associated to the Work Packages (CS Management Manual)
- Quarterly Reports of the ITDs, which inform on the resources consumption, the achievements and the resulting forecasts for level of project implementation
- Steering Committees at ITD level with involvement of the CS project officers
- Annual Reviews of the ITDs' performance organised by the JU with the involvement of independent experts.

This monitoring information is summarized and reported regularly to the Governing Board.

6. RISK ASSESSMENT

The following table presents the *Risk assessment for the year 2014*.

Risk Description	CS-process	Action Plan Summary
A late availability of ITD aircraft models for the Technology Evaluator (lack of prioritization or lack of technical inputs) could prevent the environmental benefits assessment to be efficiently performed.	<i>Manage the Programme</i>	Tightly monitor the work progress on this item through the Project Officers and the GAMs. Have preliminary models implemented where needed.
Conflicts of priorities may happen within industrial companies, or change of strategy, resulting in a lack of resources available for Clean Sky and delays in the completion of the activities.	<i>Manage the Programme</i>	Have an early warning capability through quarterly reports and alert at Governing Board level. Propose re-orientations when needed and possible.
The “share of the pie” logic could result in a lack of focus on the major, critical activities.	<i>Manage the Programme</i>	Challenge the ITDs in order that they focus on optimising the global output.
Technical setbacks in one or several ITDs may result in a significant under-spending of annual budget.	<i>Manage the Programme</i>	Re-balance the budget across ITDs and with Partners if necessary at mid-year, according to the 2 nd quarterly reports.
There is a risk that lack of pro-activity in dissemination of result may result in vague information to the end-user/interested party and therefore compromise the JU reputation	<i>Communicate</i>	Harmonize the dissemination plans of ITDs Monitor the dissemination actions

Risk Description	CS-process	Action Plan Summary
Continued understaffing could result in a continuous backlog of grant agreements and resulting payments affecting both activities progressing and budget execution of the JU both within the JU and in the ITDs.	<i>Run the Executive Team</i>	Get support from the Members according to the Statutes, and make use of framework contracts to service providers. See chapter 15. <i>JU Executive team</i> where the JU will provide opportunity for new permanent support to the executive team
The above mentioned understaffing could result in insufficient ex-ante control, resulting in an error rate above the limit of 2%	<i>Run the Executive Team</i>	Same action as above. Educate the members and apply the recently defined procedure to make sure that potential errors from previous year are checked and detected in cost claims.
The lack of experience in European Research Programmes from many Partners (SMEs) could result in a difficult and late closure process of their projects.	<i>Run the Executive Team</i>	Reinforce the information, mainly through relevant Information Days and Web conferences; reinforce the role and the awareness of Topic Managers
The potential introduction of Clean Sky 2 in parallel to Clean Sky could result in a scattering of beneficiaries' resources and a delay in Clean Sky demonstrator's finalisation.	<i>Run the Executive Team</i>	Condition the CS2 funding by SPD/TAs and by beneficiary to the actual execution of CS budgets and technical progress
The potential introduction of Clean Sky 2 in parallel to Clean Sky could result in an unbearable overload for the JU team, if not preceded by a staff increase as requested.	<i>Run the Executive Team</i>	Proceed as quickly as possible to the recruitment of the right level of staff.

The definition of the risk assessment for the year 2015 will be made at the end of 2014 when the situation will have evolved.

7. JUSTIFICATION OF THE FINANCIAL RESOURCES

Introduction

The Framework Programme 7 under which Clean Sky is funded ended in 2013. The AB 2014 therefore does not show any Commitment appropriations (CA) for 2014 coming from the EU budget. It only shows the payment appropriations (PA). The sources of revenue are the carried over appropriations from previous years, the interest gained on the bank account of Clean Sky and the revenue from members for the JU running costs.

Running costs

The running costs have been estimated based on previous years' implementation. The CA will be matched by industry each year until the end of the CS programme. The AB sets out the annual needs for running costs while keeping within the ceiling of 3% of the overall cash and in kind contributions of Members of CS.

The main features of the 2014- 2015 expenditure in the budget are set out below.

Budget Clean Sky Expenditure	Commitment Appropriations 2014	Payment Appropriations 2014	Commitment Appropriations 2015	Payment Appropriations 2015
Title 1	2,291,667	2,291,667	3,074,951	3,074,951
Title 2	1,535,226	1,535,226	1,040,302	1,040,302
Title 3	92,249,851	122,216,299	57,004,482	126,882,462
Title 5	0	27,640,835	0	0
Total Budget	123,717,579	126,043,191	61,119,736	130,997,716

Overall allocation of running costs between CS and CS2

The Joint Undertaking's common costs such as electricity, services, postal costs, stationary etc. will be divided across the 2 programmes. For 2014 the JU continues to allow Clean Sky to fund the main part of these expenses as the new programme will not start before summer 2014. Only those expenses which can directly attributed to the Clean Sky 2 programme are budgeted in the running costs for 2014 in the CS2 budget. For 2015, this will be revised.

Title 1 (Staff and associated costs):

The JU has experienced the foreseen growth of its workload and consequently the need for qualified support has grown significantly. This need is particularly important to cope with the number of reports due and arriving at the JU from its GAPs and GAMs.

Since JU has a limited number of staff and this is not foreseen to increase through its own staff plan at the beginning of 2014, JU foresees to use other possibilities to have external support to its team where possible. At present this is done through interim support and through the recent tender procedure for services from the private members.

Title 2 (Buildings, IT, Equipment, Communication, Management of Calls and Miscellaneous expenditure for running activities):

Premises

The JU will continue to be housed in the White Atrium as with the other JUs and a marginal increase in cost could be expected due to indexation on the rental contract and associated charges for the building maintenance among others. The JU foresees the need to rent further office space to house the extra staff to be recruited relating to CS2 which will be included in the CS2 part of the budget.

Grant Management Tool – next steps

In 2012 the JU started using the Grant management tool for the beneficiary information of members of the JU, i.e. the ‘programme’ grant information. A new contract for maintenance and further developments has been awarded at the end of 2013 for a period of 4 years (2013-2016) for a maximum of 500,000 €.

Communication

The Communication budget foresees the costs for the JU to participate to the air shows Farnborough in July 2014 and Paris Air Show in 2015. Other communication costs are related to organising stakeholders’ events in 2014 and 2015. The costs for these events have been included in the final AB among other communication activities foreseen.

Title 3 (Operational Expenditure):

The JU has received the detailed scope of work from all ITDs and TE for the remaining lifetime of the programme. As some ITDs chose to use multi-annual grant agreements in 2013, they do not require significant CA in 2014 but rather re-allocate unused funds from 2012 or previous years. For all ITDs, amounts have been estimated based on the figures provided to the JU. It is expected that the latter phases of the programme will produce a second year of peak of commitments in 2014 as the ITDs move ever closer to their demonstrators. It is foreseen to sign a multi-annual agreement with GRA ITD in 2014 for the remainder of the programme while SAGE ITD sees a significant peak of funding in 2014. This is linked to the scheduled activities (see related chapter above).

Grant agreements for Members (GAMs)

The model Grant Agreements for Members has been revised to cater for both annual and multi-annual grant agreements. The figures per ITD are based on the estimates received 'bottom-up' from the beneficiaries of the ITDs and TE. For information, the 2014 and 2015 ITDs estimated allocations are:

OPERATIONAL EXPENDITURE	2014	2014	2015	2015
	Commitment Appropriations (CA)	Payment Appropriations (PA)	Commitment Appropriations (CA)	Payment Appropriations (PA)
SMART FIXED WING AIRCRAFT	14,285,546	16,014,850	8,939,685	13,874,946
GREEN REGIONAL AIRCRAFT	17,202,906	6,157,343	0	10,585,042
GREEN ROTORCRAFT	12,640,872	8,217,101	8,167,663	12,169,559
SUSTAINABLE AND GREEN ENGINES	44,141,183	31,042,459	20,555,903	39,607,704
SYSTEMS FOR GREEN OPERATIONS	1,000,000	12,985,260	15,038,509	19,136,106
ECO-DESIGN	271,104	3,664,438	2,214,745	6,048,465
TECHNOLOGY EVALUATOR	0	1,533,353	2,087,976	2,512,605
CALLS FOR PROPOSALS	2,708,241	42,601,495	0	22,948,036
TITLE 3 - TOTAL	92,249,851	122,216,299	57,004,482	126,882,462

The calls for proposals budget line shows an amount of 2.7m € which covers the increase of some Grant agreements for partners up to the published threshold values where the scope of activity implied an increase in the funding to be provided to the beneficiaries concerned and as agreed with the Joint Undertaking in those specific cases.

PART B – *CLEAN SKY 2 PROGRAMME*

8. OVERVIEW OF THE CLEAN SKY 2 PROGRAMME

8.1. Meeting the Challenges set in Horizon 2020

As underlined in the EC Communication of July 2013³, progress towards the Europe 2020 objective of investing 3% of GDP in R&D has been slow, with particular weaknesses in private investments. The *Clean Sky* PPP has proven effective: delivering innovations by combining efforts from public and private stakeholders. The European Aeronautics sector today accounts for nearly half of the world's fleet in operation or on order. It is of paramount importance to the EU economy; and it helps to meet society's needs by ensuring:

- ✓ Safe, reliable and competitive mobility for passengers, goods and public services;
- ✓ Minimal impact of aviation on the environment through key innovations;
- ✓ Significant contribution to the balance of trade, economic growth and competitiveness;
- ✓ Retention and growth of highly skilled jobs, supporting Europe's *knowledge economy*.

Continued growth in demand for air travel raises new environmental and socio-economic challenges. Research and innovation has been and remains core to EU competitiveness and sustainable value creation. The long-term public-private investment made by the European Union and its Aeronautics Sector has made the industry globally competitive, allowing it to drive the innovation agenda in many areas, including environmental performance. But the new challenges identified in ACARE SRIA highlight the need for more accelerated innovation and for more far-reaching solutions. A continuation of the existing *Clean Sky* JTI will ensure new concepts are fully validated in order to accelerate the market adoption of step-change solutions. A continued PPP through *Clean Sky* 2 will deliver major gains within the key pillars defined in H2020:

- *Creating resource efficient transport that respects the environment.* *Clean Sky* 2 must finish the job of achieving the ACARE SRA goals as set for 2020.
- *Ensuring safe and seamless mobility.* New concepts will allow the air transport system to meet the mobility needs of citizens: more efficient use of local airports, faster connections, and reduced congestion.
- *Building industrial leadership in Europe.* *Clean Sky* 2 will help protect and develop highly skilled jobs within European aeronautics and its supply chain, including academia, ROs and SMEs; against a backdrop of significantly increased global competition.

By pursuing joint European research in breakthrough innovations and demonstrating new vehicle configurations in flight, *Clean Sky* 2 will position industry to invest in the development and introduction of game-changing innovations in timeframes otherwise unachievable. In doing so, it will significantly contribute to Europe's **Innovation Union**.

³ COM (2013) 494 Final: *Public-private partnerships in Horizon 2020: a powerful tool to deliver on innovation and growth in Europe*
http://ec.europa.eu/research/press/2013/pdf/jti/iip_communication.pdf

8.2. The objectives of Clean Sky 2

The renewed ACARE SRIA was completed in 2012, with ambitious goals for a sustainable and competitive aviation sector. These include a 75% reduction in CO₂ emissions, a 90% reduction in NO_x and a 65% reduction in perceived noise by 2050 compared to 2000 levels, and 4 hour door-to-door journeys for 90% of European travellers. These substantial emissions reductions and mobility goals require radically new aircraft technology inserted into new aircraft configurations. Building on the substantial gains made in *Clean Sky*, *Clean Sky 2* aims to meet the overall high-level goals with respect to energy efficiency and environmental performance shown in the following:

	<i>Clean Sky 2 as proposed*</i>
CO ₂ and Fuel Burn	-20% to -30% (2025 / 2035)
NO _x	-20% to -40% (2025 / 2035)
Population exposed to noise / Noise footprint impact	Up to -75% (2035)

* Baseline for these figures is best available performance in 2014

These figures represent the additionality of CS2 versus the 2014 Horizon 2020 Start Date and allow the full completion of the original ACARE 2020 goals (with a modest delay).

High Level Objectives for Clean Sky 2

8.3. Building on Clean Sky: the structure of Clean Sky 2

Clean Sky has demonstrated clear benefits in terms of accelerating technology development. Major developments are being made possible in different systems such as optimized wing designs, new fuselage construction concepts, energy efficient engine architectures, new flight guidance systems and ‘more electric’ on-board systems. These technological advances need to be integrated into complete aircraft to render the next generation of air vehicles more efficient and reduce emissions and noise. In addition, new vehicle configurations will have to be evaluated with flight demonstrators as they will be essential to fulfil the ambitious objectives of renewed ACARE SRIA.

Clean Sky 2 will continue to use the Integrated Technology Demonstrators (ITDs) mechanism but will also involve demonstrations and simulations of several systems jointly at the full vehicle level through Innovative Aircraft Demonstrator Platforms (IADPs). A number of key areas will be coordinated across the ITDs and IADPs through *Transverse Activities* where additional benefit can be brought to the Programme through increased coherence, common tools and methods, and shared know-how in areas of common interest. As in Clean Sky, a dedicated monitoring function - the Technology Evaluator (TE) will be incorporated in Clean Sky 2.

Innovative Aircraft Demonstrator Platforms (IADPs)

IADPs will aim to carry out proof of aircraft systems, design and functions on fully representative innovative aircraft configurations in an integrated environment and close to real operational conditions. To simulate and test the interaction and impact of the various systems in the different aircraft types, vehicle demonstration platforms are proposed covering passenger aircraft, regional aircraft and rotorcraft. The choice of demonstration platforms is geared to the most promising and appropriate market opportunities to ensure the best and most rapid exploitation of the results of *Clean Sky 2*. The “integrated IADP approach” can provide:

- Focused, long-term commitment of project partners;
- An “integrated” approach to R&T activities and interactions among the partners;
- Stable, long-term funding and budget allocation;
- Flexibility to address topics through open Call for Proposals;
- Feedback to ITDs on experiences, challenges and barriers to be resolved longer term;
- A long-term view to innovation and appropriate solutions for a wide range of issues.

Integrated Technology Demonstrators (ITDs)

In addition to the complex vehicle configurations, Integrated Technology Demonstrators (ITDs) will accommodate the main relevant technology streams for all air vehicle applications. They allow the maturing of verified and validated technologies from their basic

levels to the integration of entire functional systems. They have the ability to cover quite a wide range of technology readiness levels. Each of the three ITDs orientates a set of technology developments that will be brought from component level maturity up to the demonstration of overall performance at systems level to support the innovative flight vehicle configurations:

- Airframe comprising topics affecting the global vehicle-level design;
- Engines for all propulsion and power plant solutions;
- Systems comprising on all board systems, equipment and the interaction with the ATS

Transverse Activities

Some activities can be relevant for various IADPs and ITDs. These “Transverse Activities” do not form a separate IADP or ITD, but are an integral part of the other IADPs and ITDs. A dedicated budget will be reserved inside the concerned IADPs and ITDs to perform these activities. Leaders will be nominated for each Transverse Activity. So far, two Transverse Activities are agreed for Clean Sky 2:

- ECO-Design: life cycle optimization of the technologies, components and vehicles;
- Small Air Transport (SAT): airframe, engines and systems technologies for small aircraft, extracting synergies where feasible with the other segments.

The Technology Evaluator (TE)

A Technology and Impact Evaluation infrastructure is an essential element within the Clean Sky PPP and will be continued. Impact Assessments such as at Airport and ATS level currently focused on noise and emissions will be expanded where relevant for the evaluation of the Programme’s delivered value. Where applicable they can include the other impacts, such as the mobility or increased productivity benefits of Clean Sky 2 concepts. The TE will also perform evaluations on aircraft “Mission Level” to assess innovative long term aircraft configurations.

Membership and participation in the Clean Sky 2 Programme

Membership of *Clean Sky 2* will be comprised of:

- The European Commission representing the Union and ensuring EU public policy;
- Leaders committed to achieving the full research and demonstrator activity of the Programme
- Core-Partners with a substantial long-term commitment towards the Programme

Core-Partners will be chosen through open and competitive calls, guaranteeing a transparent selection of the best membership and strategic participation. In addition, *Partners*, *i.e.* beneficiaries selected as a result of open Calls for Proposals (CfP) will carry out actions (projects) in specific topics in the scope of a well-defined limited commitment.

With 60% of funding open to competition, *Clean Sky 2* will foster wide participation where SMEs, research organisations and academia interact directly with key industry stakeholders. Up to half of this 60% will be awarded to Core Partners who will join the JU as Members, ensuring the long term Programme stability needed to meet the relevant ACARE Goals. *Clean Sky 2* is expected to involve at least 800 participants from the European aeronautics players and also new entrants in this field.

From Clean Sky to Clean Sky 2: the principles of transition

A phased approach will be taken to the start-up of *Clean Sky 2* projects. In very broad terms, in the first 4 years *Clean Sky* developed and demonstrated technologies up to TRL4-5. From there on a selection of the most promising and mutually additive technologies are now being subsequently taken to TRL6 system level demonstration, by 2016. In some specific cases, *Clean Sky* ITDs will bring a small number of high-potential - but less mature - technologies up to TRL4 through a focused effort during the 2014-17 period. These will not be validated at TRL6 within *Clean Sky* but can be good candidates for continuation in *Clean Sky 2*.

Many *Clean Sky 2* IADPs will use results from *Clean Sky* as a start towards integration studies in the 2014-2017 timeframe. *Clean Sky* or *Clean Sky 2* ITD level outputs will form key inputs into the configuration and content of demonstrations.

The activities within *Clean Sky* will be pursued until completion according to plan. Then the technology integration may be launched in a *Clean Sky 2* IADP or, if the maturity at this point is deemed not sufficient for integration, the technology development will be continued as part of the relevant ITD. An IADP may start in *Clean Sky 2* while some of the integrated technologies have not yet passed the final validation tests. The architecture and configuration trade-off studies can be launched in an IADP as soon as the specifications and interfaces of the components and subsystems to be integrated can be frozen. Consequently, the activities within *Clean Sky* ITDs can be completed according to their own work plan at the latest in 2016 while new activities are launched within *Clean Sky 2* ITDs and IADPs according to a staggered schedule starting in 2014, the start of Horizon 2020, at the earliest.

8.4. Clean Sky 2 – Introduction to the Programme Structure and Set-up

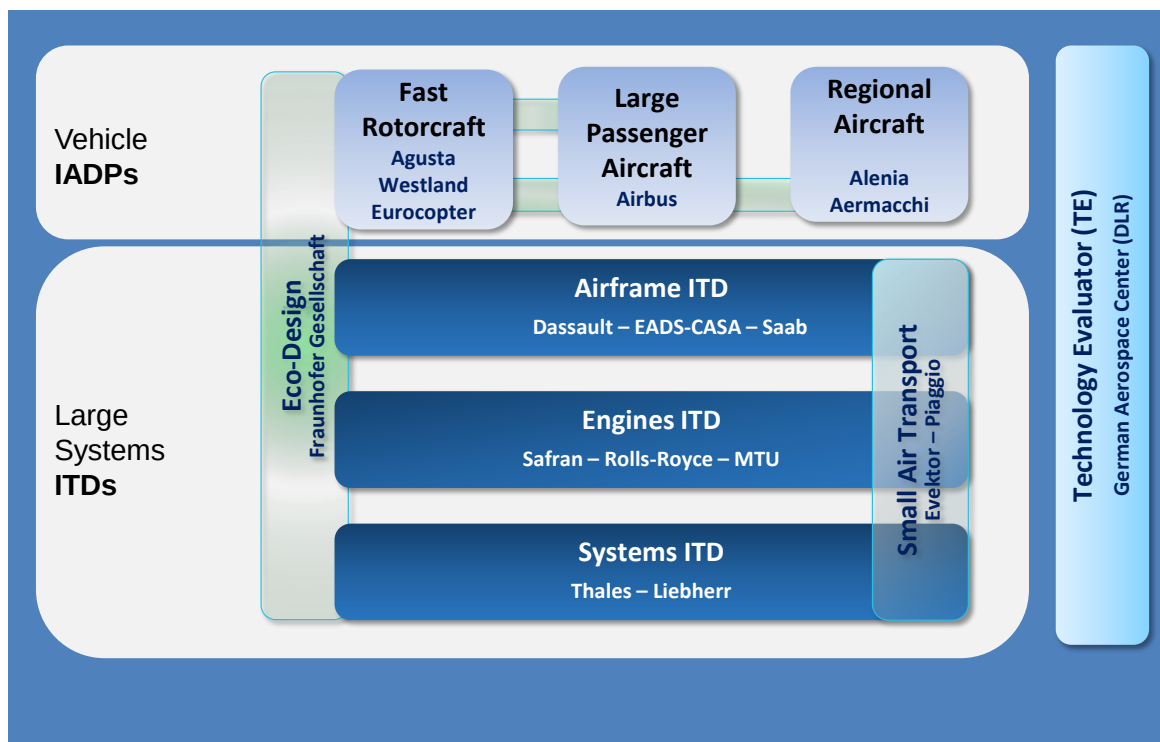
The *Clean Sky 2* Programme consists of four different elements:

- Three Innovative Aircraft Demonstrator Platforms (IADPs), for Large Passenger Aircraft, Regional Aircraft and Fast Rotorcraft, operating demonstrators at vehicle level;
- Three Integrated Technology Demonstrators (ITDs), looking at Airframe, Engines and Systems, using demonstrators at system level;
- Two Transverse Activities (Eco-Design, Small Air Transport), integrating the knowledge of different ITDs and IADPs for specific applications.
- The Technology Evaluator (TE), assessing the environmental and societal impact of the technologies developed in the IADPs and ITDs;

An overview of the distribution of the requested funding is given for the different IADPs, ITDs, TE and the Transverse Activities. The funding distribution is based on the €1.755 bn of EU funding as set out in the Clean Sky 2 regulation. Activities of the programme will go up to, and not beyond, TRL 6. They are considered to fall into the ‘Innovation actions’ category according to H2020 rules. Accordingly, they shall be funded at 70% of the eligible costs.

The overall estimated budget is €4 bn. In addition to the EU contribution (from the Horizon 2020 programme budget), the private members will contribute €2.2 bn. This includes some additional activities which are not formally part of the *Clean Sky 2* Programme as described here, but which are contributing to the objectives – enablers for the demonstrators or parallel research work necessary to develop an operational product in due time.

The structure of the *Clean Sky 2* Programme can be summarized as set out below.



The 16 *Leaders* are Members of Clean Sky 2 that will commit to deliver the full Clean Sky 2 Programme throughout its duration.

The *Core Partners* will make substantial long-term commitments towards the Programme and bring key competences and technical contributions aligned to the high-level objectives. They will contribute to the global management of the demonstrators and contribute financially with significant in-kind contributions. Core Partners will be selected on the basis of Topics for Core Partners which will be launched through the Calls for Core Partners. Applicants wishing to become Core Partners in the Clean Sky 2 Programme shall submit proposals against one or more Topics. The proposals will be evaluated and the highest ranked proposals will be selected for funding by the JU (see chapter 11).

The selected Core Partners will negotiate with the JU their accession to the Grant Agreement for Members (by signing an accession form) which will be already signed, where appropriate, between the JU and the Leaders of the relevant IADP/ITD/TA. The negotiation and accession stage will include the integration of the proposal, the work packages and technical activities of the Core Partner into the Annex I (Description of work and estimated budget) of the relevant IADP/ITD/TA Grant Agreement for Members. The Annex I will be subject to updates and revisions based on the multi-annual grant agreements framework in line with the multi-annual commitments and the programme management decision-making rules and governance framework under the CS2 Regulation.

The technical activities of the Core Partners will have to be aligned with the Programme objectives and strategic direction laid down in the Development Plan of the Clean Sky 2 Programme which will derive from the “Clean Sky 2 Joint Technical Programme” and will be referred to in the Grant Agreement for Members.

Based on the above and in the light of the specific role of the Core Partner in the implementation of the Programme and JU governance structure, other activities in addition to the technical proposal of the topic may be performed by the Core Partners and be funded by the JU. In the course of the implementation and updates of the multi-annual Programme when the implementation of other areas of the Programme require the specific key capabilities of the Core Partners and its level of technical involvement in the implementation of the ITD/IADP/TA objectives.

The JU will define on one hand, when the capabilities required and other areas of activities to be performed in an IADP/ITD/TA may be covered/absorbed by the existing level of capabilities at IADP/ITD/TA Members level, subject to a technical assessment of the JU and based on the Members multi-annual grant management process, and on the other hand when the capabilities required necessitate a call to be launched by the JU.

The *partners* will carry out objective driven research activities aiming at developing new knowledge, new technologies and solutions that will bring a contribution to one of the actions as defined in the Programme and developed in one of the IADP/ITDs/TAs.

The Partners' activities will be defined through topics proposed by the private Members of the JU to complement their research activities where appropriate. The list of topics will be defined in the Work Plan with information such as the related IADP/ITD/ TA, the title of the topic, its duration and an estimate of the topic budget value without setting a maximum threshold. The nature and value of the Topics for Partners will be smaller in terms of magnitude and duration from the Topics for Core Partners.

The private Members of the JU will propose the scope, the objectives, the duration and the estimated budget associated to the Partners' activities that will be launched through Calls for Proposals (CfP) organised by the JU. The Partners' activities will consist of tasks limited in time and scope and they will be performed under the technical monitoring of the private Member acting in the call for proposal process as topic manager (the person representing the private Member in charge of the topic).

The Calls for Proposals will be subject to independent evaluation and will follow the H2020 rules on calls for proposals. Upon selection, the Partners will sign a Grant Agreement for Partners with the JU and its contribution will be made to either the final demonstrator or the set of activities which are performed by one or several CS2 Members in the frame of the Grant Agreement for Members. Partners will not become members of the JU and will not be expected to contribute to the running costs of the JU. Similarly, they will not participate in the steering committees of the IADP/ITDs.

8.5. Overview of the Programme Research and Demonstration Activities

1) Large Passenger Aircraft IADP

The Large Passenger Aircraft IADP approach builds on the positive experience in Smart Fixed Wing Aircraft (SFWA) in *Clean Sky*. The Airbus A340-300 based BLADE laminar wing flight test demonstrator, the Airbus A340-600 based CROR demo engine flying test-bed and two different Dassault Falcon-based low speed and load control flight tests under preparation in *Clean Sky* will provide unique contributions towards maturing technologies for application in next generations of aircraft.

For *Clean Sky 2*, the Large Passenger Aircraft goal is high-TRL demonstration of the best technologies to accomplish the combined key ACARE goals with respect to the environment, fulfilling future market needs and improving the competitiveness of future products. The setup of the main programme objectives is to further push the value of technologies tackled in *Clean Sky*, e.g. the integration of CROR propulsion systems, and to add the validation of additional key technologies like hybrid laminarity for the wing, horizontal and vertical tail plane as well as an all-new next generation fuselage cabin and cockpit-navigation suite validated at integrated level with large scale demonstrators in operational conditions.

The focus is on large-scale demonstration of technologies integrated at aircraft level in three distinct ‘Platforms’:

- **Platform 1 “Advanced Engine and Aircraft Configurations”** will provide the environment to explore and validate the integration of the most fuel efficient propulsion concept for next generation short and medium range aircraft, the CROR engine. Large scale demonstration will include extensive flight testing with a full size demo engine mounted to the Airbus A340-600 test aircraft, and a full size rear end structural ground demonstrator. Two demonstrators are planned to mature the concept of “hybrid laminarity” targeting for a substantial aerodynamic drag reduction for next generation long range aircraft. A further demonstration is planned for a comprehensive exploration of the concept of dynamically scaled flight testing. The target is to examine the representativeness of dynamically scaled testing for technology demonstration with highly unconventional aircraft configuration, which means flight test demonstrations that are virtually impossible with modified “standard” test aircraft.
- **Platform 2 “Innovative Physical Integration Cabin – System – Structure”** aims to develop, mature, and demonstrate an entirely new, advanced fuselage structural concept developed in full alignment towards a next generation cabin-cargo architecture, including all relevant principle aircraft systems. To be able to account for the substantially different requirements of the test programs, the large scale demonstration will be based on three individual major demonstrators. A lower centre section fuselage and one “typical” fuselage stretching from aft of the center section to the pressure bulkhead will be developed, manufactured and tested with focus on loads and fatigue aspects. A further “typical” fuselage demonstrator will be dedicated to integrate and test a next generation of

large passenger aircraft cabin and cargo. A number of smaller test rigs and component demonstrators will also be part of the Programme in the preparatory phase. Targeting to accomplish technology readiness level 6, manufacturing and assembly concepts for the next generation integrated fuselage-cabin-cargo approach will be developed and demonstrated.

- **Platform 3 “Next Generation Electrical Aircraft System, Cockpit and Avionics”** has a clear focus to develop and demonstrate a next generation cockpit and navigation suite. Based on the results of a number of research programmes which are currently ongoing or to be started shortly, platform 3 shall allow the Programme to integrate and validate all functions and features which are emerging from individual developments into a disruptive new concept in a major demonstrator suite. With the core of platform 3 being a major ground based demonstrator, selected features and functions will be brought to flight test demonstration. The scope of platform 3 will cover the development of a new next generation cockpit concept, a rethinking towards a “function” based cockpit to operate the aircraft, specifically including all navigation and flight guidance features and function required to incorporate next generation flight and trajectory management capabilities.

2) Regional Aircraft IADP

Regional aircraft are a key element of *Clean Sky* through a dedicated ITD - Green Regional Aircraft (GRA), providing essential building blocks towards an air transport system that respects the environment, ensures safe and seamless mobility, and builds industrial leadership in Europe. In *Clean Sky 2* the Regional Aircraft IADP will bring the integration of technologies to a further level of complexity and maturity than currently pursued in *Clean Sky*. The goal is to integrate and validate, at aircraft level, advanced technologies for regional aircraft so as to drastically de-risk their integration on future products.

The following demonstration programmes for regional aircraft a/c are currently foreseen:

- 2 Flying Test-beds (to minimize the technical and programme risks) using modified existing regional TP a/c with underwing mounted engines, for demonstration campaigns of: air vehicle configuration technologies; wing structure with integrated systems and propulsion integration; flight dynamics, aerodynamic and load alleviation; advanced flight controls and general systems, and avionics functionalities.
- 5 Large Integrated Ground Demonstrators: full-scale wing, full-scale cockpit; full-scale fuselage and cabin; all including their associated systems; flight simulator; iron bird. In addition a Nacelle ground demonstrator will be done in the Airframe ITD.

Full-scale demonstrations, with acceptable risk and complexity but still providing the requested integration, are essential to allow the insertion of breakthrough technologies on regional aircraft entering into service from 2025. The individual Technology Developments are arranged along with 8 “Waves” and several individual roadmaps. These technology

waves will be developed through roadmaps defined to satisfy the high-level requirements of the future Highly-Efficient Next Generation Regional Aircraft, the configuration of which will be developed at conceptual level in a dedicated work package. To increase synergies and cross fertilization across the different ITDs and IADPs some of the above technological roadmaps will be shared with the “streams” of the Airframe ITD and with the developments of sub-systems and systems planned inside Systems and Engine ITD. The Demonstration Programme will be divided into technologically compatible and “scope close” demonstrations sub-programmes:

- **FTB1 - Innovative Wing and Flight Controls (Regional IADP):** Integration and flight testing of technologies suitable to regional aircraft applications for a new generation wing and advanced flight control systems. Innovative wing related systems and wing structural solutions will also be incorporated where feasible. Aerodynamic enhancements and LC&A features will be considered to complement FTB2, such as: outboard wing featuring laminar airfoils for skin friction reduction; high A/R by means of adaptive/innovative winglets.
- **FTB2 - Flight Demonstration of a high efficient and low noise Wing with Integrated Structural and related Systems solution, including power plant aspects (Regional IADP):** A new wing will be designed, manufactured and equipped with new structural solutions strongly integrated with advanced low power and high efficient systems such as ice protection, fuel, flight control, engine systems, LE and winglets morphing.
- **Full-scale innovative fuselage and passenger cabin (Regional IADP)::** Integration and on-ground testing of a full scale innovative fuselage and passenger cabin including all the on board systems and advanced solutions for increasing passenger comfort and safety. The fuselage will be a full scale demonstration of technologies for composite material, structures and manufacturing aimed to weight and cost reduction and to minimize the environmental impact through eco-design and energy consumption optimization all along the life-cycle (towards a zero-impact).
- **Flight Simulator (Regional IADP):** Starting from the *Clean Sky* GRA Flight Simulator, an advanced Flight Simulator will be set up and used to demonstrate new cockpit interaction concepts as well as advanced avionics functionalities.
- **Iron Bird (Regional IADP):** Virtual and Physical “Iron Birds” will also be an important part of the Regional A/C Ground Demonstration Programme. These will be used to integrate, optimize and validate the systems modification of the Flying Test Bed and the results of their simulations and ground testing will be essential to achieve the permit-to-fly.
- **Ground Demonstration of the wing (Airframe ITD),** including the airframe and the related systems.
- **Ground Demonstration of the Cockpit (Airframe ITD),** including the structure and related system.
- **Nacelle ground demonstration (Airframe ITD).**

3) Fast Rotorcraft IADP

The Fast Rotorcraft IADP consists of two separate demonstrators, the Tiltrotor demonstrator and the Compound Rotorcraft demonstrator.

The Fast Rotorcraft IADP consists of two concurrent demonstrators, the Tiltrotor demonstrator and the Compound Rotorcraft demonstrator along with transversal activities relevant for both fast rotorcraft concepts.

- **Joint activities:**

These activities cover the methodology for technology evaluation of fast rotorcraft demonstrations and the Eco-Design concept implementation, along with the programme management activities for the Fast Rotorcraft IADP.

Concerning the methodology for technology evaluation, the activities will allow defining SMART objectives and criteria adapted to the fast rotorcraft missions in line with the general TE approach for *Clean Sky 2*. In addition, the tools used in GRC1-GRC7 will be adapted and further developed in order to enable the assessment of conceptual rotorcraft models corresponding to the new configurations to be demonstrated.

Concerning Eco-Design concept implementation, the activities will allow coordinating approaches and work plans in the two demonstration projects regarding the greening of rotorcraft production processes and ensuring complementarity of case studies. The general Life Cycle Assessment approach will be coordinated with the participants of the Eco-Design TA.

- **The Tiltrotor demonstrator NextGenCTR:**

NextGenCTR will be dedicated to design, build and fly an innovative next generation civil tiltrotor technology demonstrator, the configuration of which will go beyond current architectures of this type of aircraft. NextGenCTR's demonstration activities will aim at validating its architecture; technologies/systems and operational concepts. Demonstration activities will show significant improvement with respect to current Tiltrotors' state-of-the-art. The project will also allow to develop substantial R&T activities to increase the know-how about a new platform like a tiltrotor (not yet certified as a civil aircraft), and to generate a research and innovation volume of activities above a certain critical mass (not available today for Tiltrotors within EU), somewhat comparable to that of well proven conventional helicopter platforms.

NextGenCTR will continue and further develop what has been initiated in Clean Sky, and launch new activities specific to Clean Sky 2 and NextGenCTR project. In the area of CO₂ emissions reduction, NextGenCTR will continue/develop engine installation and flight trajectories optimisation (this is now done by analytical models and with scaled model tests, whereas Clean Sky 2 will validate it at full scale), while specific Clean Sky 2 new activities on drag reduction of the prop-rotor and airframe fuselage and wing will be

necessary (due to a new generation of prop-rotor, modified fuselage-wing architecture). This latter Clean Sky 2 specific topic will also be related to operation costs reduction to address competitiveness of the architecture and solutions adopted. The new prop-rotor will require substantial research (aero-acoustics, by modelling/by tests) to reduce noise emissions (then validated at full scale); in the current Clean Sky, noise reduction is mainly addressed through trajectories optimisation (that will anyhow continue in Clean Sky 2 and will be linked to SESAR concepts where necessary). Clean Sky 2 transversal subjects will cover new material (e.g. thermoplastics, surface treatments, less hydraulics and more electrical systems) validating them at full scale and in real operational conditions, and sustain the development of the Technology Evaluator for the case of the tiltrotor (today not widely considered).

Parameters need to be defined to show Clean Sky 2 achieved progress according to a specific tiltrotor roadmap (a direct comparison with conventional helicopter architecture seems not appropriate as the two configurations must be regarded as substantially different types of rotary-wing platforms). Today, certified Tiltrotors are not available in the civil sector (while only one product is available in the military); hence, a database from which baseline information for the current state-of-the-art can be extracted is not available. Therefore, 'key performance parameters' (KPP) will be introduced to show NextGenCTR's progress with respect to reference data taken as baseline (mainly referring to technologies which have been tested or conceptually designed in the period 2005-2012). Objectives will be defined considering tiltrotor specificities and in line with the main pillars of Horizon 2020 towards a Smart, Green and Integrated Transport and Clean Sky 2 which addresses environmental compatibility (Greening Objectives), competitiveness (Industrial Leadership) and mobility. Considerable attention to the project's impact on EU Economy and Jobs creation will be considered, to confirm and further sustain a steady growth of the sector with regard to revenues, workforce productivity, high rate of new employment (in particular of higher educated personnel) and R&D expenditure.

- **The Compound Rotorcraft demonstrator:**

The LifeRCraft project aims at demonstrating that the compound rotorcraft configuration implementing and combining cutting-edge technologies as from the current Clean Sky Programme opens up new mobility roles that neither conventional helicopters nor fixed wing aircraft can currently cover in a way sustainable for both the operators and the industry. The project will ultimately substantiate the possibility to combine in an advanced rotorcraft the following capabilities: payload capacity, agility in vertical flight including capability to land on unprepared surfaces nearby obstacles and to load/unload rescue personnel and victims while hovering, long range, high cruise speed, low fuel consumption and gas emission, low community noise impact, and productivity for operators.

A large scale flightworthy demonstrator embodying the new European compound rotorcraft architecture will be designed, integrated and flight tested. This demonstrator will

allow reaching the Technology Readiness Level 6 at whole aircraft level in 2020. The project is based on:

- identified mobility requirements and environmental protection objectives;
- lessons learnt from earlier experimentation with the low scale exploratory aircraft X^3 ;
- technology progress achieved for rotorcraft subsystems on one side through participation to *Clean Sky* projects and other research activities at EU or local level;

The individual technologies from the first Clean Sky Programme (Green Rotorcraft ITD, Smart Green Operations ITD, Eco-Design ITD) that will be further matured and integrated in this LifeRCraft demonstration concerns:

- New rotor blade concepts aiming rotor blade concepts aiming at improved lifting efficiency and minimum noise esp. through 3D-optimised shape; the methodology and computational tools required for such optimization;
- Airframe drag reduction through shape modifications and interference suppression;
- Engine intake loss reduction and muffling;
- Innovative electrical systems e.g. brushless generators, high voltage network, efficient energy storage and conversion, electrical actuation designed for weight and on-board energy savings;
- Eco-Design approach, with substitution of harmful materials by new ones and green production techniques, demonstrated for specific rotorcraft components;
- Helicopter fly-neighbourly demonstration based on new flight guidance function and specific approach procedures in both VFR conditions and ATM, SESAR-compliant;

This LifeCraft project essentially consists of the following main activities and deliveries:

- **Airframe structure and landing system:** Advanced composite or hybrid metallic/composite construction, featuring low weight and aerodynamic efficiency;
- **Lifting rotor and propellers:** Low drag hub, pylon and nacelles, 3D-optimized blade design;
- **Drive train and power plant:** New drive train architecture and engine installation optimised for the LifeRCraft configuration;
- **On board energy, cabin and mission systems:** Implementation of the more electrical rotorcraft concept to minimise power off-takes from the engines and drive system;
- **Flight control, guidance and navigation:** Smart flight control exploiting additional control degrees of freedom inherent to LifeRCraft configuration for best fuel economy and quieter flight;
- **LifeCraft Demonstrator overall design, integration and testing:** All coordination and cross cutting activities relevant to the whole vehicle delivering a full range of ground & flight test results and final conclusion.

4) Airframe ITD

Aircraft level objectives on greening, industrial leadership and enhanced mobility, and the fulfilment of future market requirements and contribution to growth cannot be met without strong progress on the airframe. A more efficient wing with natural laminar flow, optimised control surfaces and control systems will be demonstrated in Clean Sky. Also, novel engine integration strategies will have been derived and tested, and innovative fuselage structures investigated.

Altogether strong progress towards the 2020 targets will have been obtained when *Clean Sky* is completed (estimated at 75% of the relevant part of the initial ACARE goals, applicable to aircraft with an EIS from 2020/22). However further progress is required on the most complex and challenging requirement on new vehicle integration to fully meet the 2020 objective, and to progress towards the 2050 goals. To make this possible, different directions are proposed. All of these directions of progress will be enabled throughout the foreseen execution of 9 major Technology Streams:

- **Innovative Aircraft Architecture**, to investigate some radical transformations of the aircraft architecture.
The aim of this Technology Stream is to demonstrate the viability of some most promising advanced aircraft concepts (identifying the key potential showstoppers & exploring relevant solutions, elaborating candidate concepts) and assessing their potentialities.
- **Advanced Laminarity** as a key technological path to further progress on drag reduction, to be applied to major drag contributors: nacelle and wing;
This Technology Stream aims to increase the Nacelle and Wing Efficiencies by the mean of Extended Laminarity technologies.
- **High Speed Airframe**, to focus on the fuselage & wing step changes enabling better aircraft performances and quality of the delivered mobility service, with reduced fuel consumption and no compromise on overall aircraft capabilities (such as low speed abilities & versatility).
- **Novel Control**, to introduce innovative control systems & strategies to gain in overall aircraft efficiency. The new challenges that could bring step change gains do not lay in the optimisation of the flight control system component performing its duty of controlling the flight, but in opening the perspective of the flight control system as a system contributing to the global architecture optimization. It could contribute to sizing requirements alleviations thanks to a smart control of the flight dynamics.
- **Novel Travel Experience**, to investigate new cabins including layout and passenger oriented equipment and systems. The cabin interiors progress is indeed on the path of all societal challenges of the future transport system:
 - As a key enabler of product differentiation,
 - As having an immediate & direct physical impact on the traveller,
 - As having a great potential in terms of weight saving & eco-compliance.
- **Next Generation Optimized Wing Boxes**, leading to progress in the aero-efficiency and the ground testing of innovative wing structures;

The challenge is to develop and demonstrate new wing concepts (including architecture) that will bring significant performance improvements (in drag & weight) while improving affordability and enforcing stringent environmental constraints.

- **Optimized High Lift Configurations**, to progress on the aero-efficiency of wing, engine mounting & nacelle integration for aircraft who needs to serve small, local airports thanks to excellent field performances.
- **Advanced Integrated Structures**, to optimize the integration of systems in the airframe along with the validation of important structural advances and to make progress on the production efficiency and manufacturing of structures.
- **Advanced Fuselage** to introduce innovation in fuselage shapes and structures, including cockpit & cabins. New concepts of fuselage are to be introduced to support the future aircrafts and rotorcrafts. More global aero structural optimizations can lead to further improvements in drag & weight in the context of a growing cost & environmental pressure, including emergence of new competitors.

Due to the large scope of technologies undertaken by the Airframe ITD, addressing the full range of aeronautical portfolio (Large passenger Aircraft, Regional Aircraft, Rotorcraft, Business Jet and Small transport Aircraft) and the diversity of technology paths and application objectives, the above technological developments and demonstrations are structured around 2 major Activity Lines, allowing to better focus the integrated demonstrations on a consistent core set of user requirements, and, when appropriate, better serve the respective IADPs:

- Activity Line 1: Demonstration of airframe technologies focused towards **High Performance & Energy Efficiency (HPE)**;
- Activity Line 2: Demonstration of airframe technologies focused toward **High Versatility and Cost Efficiency (HVE)**.

5) Engines ITD

In Clean Sky the industry leaders committed to build and test five engine ground demonstrators covering all the civil market. The goals were to validate to TRL 6 a 15% reduction in CO₂ compared to 2000 baseline, a 60% reduction in NO_x and a 6dB noise reduction. This is roughly 75% of the ACARE objectives. Following the worst economic downturn and the consequent changes to market assumptions *Clean Sky's* SAGE has adjusted its content to ensure these goals remain achievable. Apart from the consequent delay to the open rotor programme which means that TRL6 is not possible by 2016, the bulk of SAGE objectives remain on track. An open rotor ground demonstrator will run and confirm the CO₂ objective, a lean burn combustion ground demonstrator will run to confirm the NO_x objective and a GTF will run to confirm the CO₂ improvements and noise advantage of such a configuration. An advanced turbo-shaft engine has already run to ensure the environmental goals extend across the whole market while SAGE 3 has run for the first time to validate the cost and weight advantages of an advanced dressings configuration. The original plans for the open rotor from both Airbus and the engine manufacturers had to be revised and require further work to confirm both the advantages and credibility of this novel concept.

For *Clean Sky 2*, Engines ITD will build on the success of SAGE to validate more radical engine architectures to a position where their market acceptability is not determined by technology readiness. The platforms or demonstrators of these engines architectures are summarized below:

- **Open Rotor Flight Test, 2014-2019:** A 2nd version of a Geared Open Rotor demonstrator carrying on *Clean Sky* SAGE 2 achievements and aimed to validate TRL 6 will be tested on ground and then on the Airbus A340 flying test bed (see IADP LPA Programme). From initial SAGE 2 demonstrator some engine modifications aimed to various improvements, control system update, and engine/aircraft integration activities will be necessary.
- **Ultra High Propulsive Efficiency (UHPE) demonstrator addressing Short / Medium Range aircraft market, 2016-2022:** Design, development and ground test of a propulsion system demonstrator to validate the low pressure modules and nacelle technology bricks necessary to enable an Ultra High By-pass Ratio engine (e.g. advanced low pressure fan, innovative nacelle modules, gearbox, pitch change mechanism if any, high speed power turbine). This ground demonstrator will be built around an existing high pressure core.
- **Business aviation / Short range regional Turboprop Demonstrator, 2014-2019:** Design, development and ground testing of a new turboprop engine demonstrator in the 1800-2000 shp class. Base line core of ARDIDEN3 will be improved specifically for turboprop application (compressor up-date, combustion chamber, power turbine) and then integrated with innovative gear box, new air inlet and innovative propeller.

- **Advanced Geared Engine Configuration (HPC and LPT technology demonstration), 2015-2020:** Design, development and ground testing of a new demonstrator to validate key enablers to reduce CO₂ emissions and noise as well as engine weight. Key elements are: improvement of efficiencies, reduction of parasitic energy flows, innovative lightweight and temperature resistant materials, low pressure turbine and exhaust noises reduction.
- **Very High Bypass Ratio (VHBR) Large Turbofan demonstrator, 2014-2019:** Design, development, building, ground testing and flight testing of an engine to demonstrate key technologies on a scale suitable for large engines. An existing engine will provide the core gas generator used for the demonstrator. Key technologies included in this demonstrator will be: integrated low pressure system for a high power very-high bypass ratio engine (fan, compressor, gearbox, LP turbine, VAN), Engine core optimisation and integration, and optimised control systems.
- **Very High Bypass Ratio (VHBR) Middle of Market Turbofan technology, 2014-2018:** Development and demonstration of technologies in each area to deliver validated powerplant systems matured for implementation in full engine systems. Research and demonstration will require the following: behaviour of fans at low speeds and fan pressure ratios and structural technology, aerodynamic and structural design of low pressure turbines for high speed operation, Systems Integration of novel accessory and power gearboxes, optimised power plant integration, Compressor efficiency, and control & electrical power system technology developments.
- **The Small Aero-Engine Demonstration** projects related to SAT [Small air Transport] will focus on small fixed-wing aircraft in the general aviation domain, and their power-plant solutions spanning from piston/diesel engines to small turboprop engines. As the demonstration project on business aviation and short-range regional turboprop aircraft (see above) will demonstrate the reliability and efficiency gains in small turbine engines, this area in the Engines ITD will focus on light weight and fuel efficient diesel engines (including the potential exploitation of the 300 kW helicopter engine launched through a CfP under the current *Clean Sky*); and potential hybrid engine architectures (piston/electric engine). In addition (within the overall SAT project scope), the development and use of low-noise, highly efficient propellers (aimed at hybrid engine, small turbines, diesel engines) will be undertaken.

7) Systems ITD

While systems and equipment account for a small part of the aircraft weight and environmental footprint, they play a central role in aircraft operation, flight optimisation, and air transport safety at different levels:

- Direct contributions to environmental objectives: optimised green trajectories, electrical taxiing, more electrical aircraft approach, and have a direct impact on CO₂ emissions, fuel consumption, perceived noise, air quality, weight gain.
- Enablers for other innovations: for example, bleedless power generation, actuators, are necessary steps for the implementation of innovative engines or new aircraft configurations.
- Enablers for air transport system optimisation: many of the major improvements identified in SESAR, NextGen and *Clean Sky* for greening, improved mobility or ATS efficiency can only be reached through the development and the integration of on-board systems such as data link, advanced weather systems, trajectory negotiation, and flight management predictive capabilities.
- Smart answers to market demands: systems and equipment have to increase their intrinsic performance to meet new aircraft needs without a corresponding increase in weight and volume: kW/kg, flux/dm³ are key indicators of systems innovation.

In *Clean Sky*, the Systems for Green Operations ITD has developed solutions for more efficient aircraft operation. Further maturation and demonstration as well as new developments are needed to accommodate the needs of the next generations of aircraft. In addition, the systemic improvements initiated by SESAR and NextGen will call for new functions and capabilities for environmental or performance objectives, but also for flight optimisation in all conditions, flight safety, crew awareness and efficiency, better maintenance, reduced cost of operations and higher efficiency. Finally, framework improvements will be needed to allow for more efficient, faster and easier-to-certify development and implementation of features and functions.

The Systems ITD in *Clean Sky 2* will address these challenges through the following actions:

- Work on specific topics and technologies to design and develop individual equipment and systems and demonstrate them in local test benches and integrated demonstrators (up toTRL 5). The main technological domains to be addressed are cockpit environment and mission management, computing platform and networks, innovative wing systems (WIPS, sensors, and actuators), landing gears and electrical systems. Other contributive activities are foreseen and will be carried on by core partners and partners. The outcome of these developments will be demonstrated systems ready to be customized and integrated in larger settings. An important part of this work will be to identify potential synergies between future aircraft at an early stage to reduce duplication.

- Customisation, integration and maturation of these individual systems and equipment in IADPs demonstrators. This will enable full integrated demonstrations in IADPs and assessment of benefits in representative conditions.
- Transverse actions will also be defined to mature processes and technologies with potential impact on all systems, either during development or operational use. Examples of these transverse actions can be development framework and tools, simulation, incremental certification, integrated maintenance, eco-design etc.

8) Small Air Transport (SAT) Transverse Activity

The SAT Initiative proposed in *Clean Sky 2* represents the R&T interests of European manufacturers of small aircraft used for passenger transport (up to 19 passengers) and for cargo transport, belonging to EASA's CS-23 regulatory base. This includes more than 40 industrial companies (many of which SMEs) accompanied by dozens of research centres and universities. The New Member States industries feature strongly in this market sector. The community covers the full supply chain, i.e. aircraft integrators, engine and systems manufacturers and research organizations.

The approach builds on accomplished or running FP6/FP7 projects. Key areas of societal benefit that will be addressed are:

- Multimodality and passenger choice
- ore safe and more efficient small aircraft operation
- Lower environmental impact (noise, fuel, energy)
- Revitalization of the European small aircraft industry

To date, most key technologies for the future small aircraft have reached an intermediate level of maturity (TRL3-4). They need further research and experimental demonstration to reach a maturity level of TRL5 or TRL6. The aircraft and systems manufacturers involved in SAT propose to develop, validate and integrate key technologies on dedicated ground demonstrators and flying aircraft demonstrators at an ITD level up to TRL6. The activity will be performed within the *Clean Sky 2* ITDs for Airframe, Engines and Systems; with strong co-ordinating and transversally integrating leadership from within a major WP in Airframe ITD.

9) Eco-Design Transverse Activity

Eco-Design will research for a roadmap of excellence, to give high (European) individuality in quality and eco-compliance in the aeronautics vehicles⁴, in their whole product life. Eco-Design is reshaped from the former two domain concept – “Airframe” and “Systems” – to transformed, interfacial sub-activity areas that are more open and entrepreneurial. These are:

- The Eco-Design Analysis (EDAS) activity for next concept (full) REcycle and commensurate Eco-Design Life.
- All pillars of life value are addressed, beyond the conventional “cradle to grave” philosophy, to stimulate better RE-Use options and new, best know-how service options, embracing all the supply chain and OEM actors. Eco-Design Analysis is a knowledge & responsibility empowerment, addressing more widened stakeholder suitability. It shall open up a new supplier/SME interaction basis, and will serve better to grasp full *ground pollution*⁵ issues and catalyse more clean and efficient processes for improved economic and societal return.
- Eco-Design principles should be owned by all new programmes and contributors to them. The analysis shall program Eco-Design as enthusiasm value partner for user benefit analyses of the IADP/ITD (acceptance and repeatability, ergonomics and flair, competitive edge value, ecological and economic asset improvement).
- The Vehicle Ecological, Economic Synergy (VEES) activity, that is driven from Materials, Processes, Resources (MPR) innovations, secondly from the assimilation of cooperative modules from the ITD/IADP demonstrators with an adaptive Eco Hybrid Platform (EHP), which is totally “LCA+” (Life Cycle Analysis-plus) design driven and an open platform on the level of complete vehicles. This is networked with clustered REcycle for REuse ground facility realisations. LCA+ is used as a receiving-end methodology from the developing Design for Environment (DfE) vision. Eco-Design work units inside the sub-activities give a practical footing, always relating to the *Eco-Design Life and REcycle*-theme reference, see below this section, tracked by the transversal coordination. Eco-Design ensures a collective vision of these themes on-board the various ITD/IADP technology streams.

“Eco Architectures”, as one example, covers the main eco-footprint impact on the vehicle from systems performance and indirect energy, water etc. consumption. Close co-operation for these outputs from the major physical benches (electrical, consumer heat output, etc.) will be incorporated. ITD/IADP advanced optimisation methodologies, special physical frame architecture concepts such as next Thermal Frame Benches, Fluid Management Benches etc. will help new *interface trade-offs research*, that fortifies the straight-to-the-point ecologonomics in energy, water/air footprints results.

⁴ Includes also Engine and Systems, and regardless of aircraft, rotorcraft frame definition.

⁵ Global Warming Potential of substances equated to CO₂-impact, negative potentials on health and bio diversity, depletion of resources, primary energy demand.

In the work units' concept, *ECOTech* units of clear universal issues (e.g. on corrosion, surface treatments, fire, contamination etc.) will be implemented. Eco-Design will upkeep a sophisticated MPR-Database suitable for aeronautics from the initial *Clean Sky* achievement, offer technical workshops for exchange on LCA, the discourse on DfE, REACH, RoHS, evolving European Standards impacts (indirect water consumption etc.), on concerns such as primary energy demand in production with cost knock-on.

A deeper Eco-Design Statements (ES) concept will ensure the best developed Eco-Design recommendation guidelines come from these collaborative sub-activity areas. Stakeholder balanced consultation and user benefit analyses in the so-called *ecolonomic harmonisation* process will be exercised on different micro-economic tiers with industrialization scoping to produce well backed socio-economic derivative data; this includes quality labour growth impacts or remedial volumes to tackle and suppress any ground pollution sensitivities. The closure on its material flow and logistics' output is given through close co-operation with TE in the ITD/IADP top level aggregate delivery.

Eco-Design delivery focuses on quality, eco-compliance and processes whereas the ITDs/IADPs are front lining the TRL-maturity in the technology streams with component application identity. Together, this will raise the technology strengths in the new *Clean Sky 2* Programme.

Eco-Design will deliver success by:

- demonstrating Eco-Design interaction through the ITD/IADP (through shared components contributing to process optimality and eco-compliance up to a/c level),
- bringing all the ITD/ IADPs really on board, for instance for the Eco Statements (ES) having consistent and validated process improvements for the technology take-up into big impact technology pathways,
- generating master scientific approaches to match eco-quality and -compliance to high technology readiness promoted through the ITD/IADP,
- creating user enthusiasm value feed-back through Eco-Design principles
- reducing down-cycling, no-future technology down-selection and withdrawal menaces.
- MPR database enhancing EU competitiveness dimension.

Key Eco-Design & REcycle themes:

Identification and Life Information Strategy (not a copy of SHM), MPR, manufacture & production, services to component and system (MRO, Finances/IT Know-How, limited life and extended life integration, inside-outside gate synergy processes), Integration/field-assembly-disassembly-separation, RE-Use, End of Life, Alternative Sectoral Applications, Use Phase (TE feed-back, vehicle utilization closure; eco-values).

10) Technology Evaluator

A Technology and Impact Evaluation project organization and infrastructure was and remains an essential element within the *Clean Sky* PPP, and will be continued. Impact assessments evaluating the performance potential of the *Clean Sky* 2 technologies both at vehicle level and at relevant aggregate levels such as at Airport and ATS level, and currently focused on noise and emissions, will be retained. Where appropriate and agreed jointly within the JU Membership they may be expanded to include other relevant environmental or societal impacts, such as mobility benefits or increased productivity.

The analysis of single or logically grouped core technologies on system / vehicle level will be embedded within the IADPs and ITDs, with the TE taking an integrative and ‘synthetic’ approach focusing on the relevance of the *Clean Sky* 2 output on the Aviation Sector and simulating Air Transport System Impacts. Therefore, the core aircraft performance characteristics (at the so-called ‘mission level’) will be reported by the IADPs, with clear assigned responsibilities, resource and project tasks embedded in each IADP. Reporting the mission level aircraft capability will reside under the responsibility of the leading company. The IADPs will provide verification and validation of the performance modelling, so as to certify validity of performance predictions. Impact Assessment will be the responsibility of the TE / Impact Evaluator and will focus on aggregate impacts.

For those *Clean Sky* 2 ITDs technologies not feeding into an IADP aircraft model, the TE will build up its own Mission Level assessment capability, also to assess innovative long term aircraft configurations. Thus, an aircraft-level synthesis of these results via ‘concept aircrafts’ is possible and the respective ITD results can be shown at aircraft level and evaluated within the Airport and Air Transport System alongside the IADP results.

Finally, the progress of each demonstration platform (ITDs and IADPs) will be monitored against the defined environmental and socio-economic benefits and targets via an efficient and effective interfacing between the TE and the ITDs and IADPs. For this, dedicated work packages in the TE (WP2) as well as in the ITDs and IADPs are intended.

In summary, the Technology Evaluator consists of three major tasks:

- Progress Monitoring of *Clean Sky* 2 achievements vs. defined environmental and societal objectives;
- Evaluation at Mission Level by integrating particular ITD outputs into TE concept aircraft / rotorcraft models;
- Impact Assessments at Airport and ATS Level using IADPs and TEs concept aircraft / rotorcraft models.

8.6. Summary of Major Demonstrators and Technology Developments

The table below summarizes the major demonstrators and technology developments foreseen over the life of the Programme. Supporting activities not directly embedded into a demonstrator are listed separately. The funding required for the running costs of the Joint Undertaking as well as for the Technology Evaluator are taken into account through a dedicated budget calculated in accordance with the CS2 Statutes. For the Eco-Design and Small Air Transport Transverse Activities the funding is embedded within the IADPs and ITDs funding amounts.

Note activities highlighted as follows: these are currently under further preparation and revision and will be subject to a Technical Evaluation.

<u>IADP / ITD</u>	<u>Technology Areas</u>	<u>Demonstrator / Technology Stream</u>	<u>Technologies</u>	<u>Reference Chapter</u>	<u>Complete by</u>	<u>ROM EC funding (in M€)</u>
Large Passenger Aircraft	Advanced Engine Design & Integration for Large Passenger Aircraft	CROR demo engine flight test demo & NPE Demonstration	performance noise, vibration NPE activities	6.5.2	2020	93
		Advanced engine integration driven fuselage ground demonstrator	- CROR structure and system integration	6.5.3	2020	39
			- Full CFRP fuselage			
		Validation of scaled integrated flight testing	Potential unique enabler for demo of advanced a/c configuration at full aircraft level	6.5.4	2020	5
Large Passenger Aircraft	Advanced Laminar Flow Drag Reduction for Large Passenger Aircraft	HLFC large-scale specimen demonstrator in flight operation	Aerodynamic drag reduction through laminar flow for L/R aircraft at high transonic speed	6.5.5	2020	29
		High speed demonstrator with hybrid laminar flow control wing	Aerodynamic drag reduction through laminar flow for L/R, high transonic	6.5.5	2020	39

<u>IADP / ITD</u>	<u>Technology Areas</u>	<u>Demonstrator / Technology Stream</u>	<u>Technologies</u>	<u>Reference Chapter</u>	<u>Complete by</u>	<u>ROM EC funding (in M€)</u>
			speed			
Large Passenger Aircraft	Innovative Flight Operations	Innovative Flight Operations	Next generation ATM and MTM functionalities	6.5.6	2020	18
	Demonstration of Radical Aircraft Configurations	Demonstration of advanced short-medium range aircraft configuration	Demo of a target a/c configuration with combinations of disruptive technologies	6.5.7	2020	47
Large Passenger Aircraft	Innovative Cabin & Cargo Systems and Fuselage Structure Integration for Large Passenger Aircraft	Next generation fuselage, cabin and systems integrated Demonstrator	Advanced fuselage architecture fully integrated next generation cabin & cargo concepts and systems	6.6.3	2020	69
		Next generation Cabin-Cargo Functional Demonstrator	Cabin functionalities, advanced networks for energy and data transfer, Cabin flexibility, Cabin ergonomics, human centered cabin	6.6.3	2020	34
		Next Generation lower centre Fuselage Demonstrator	Advanced fuselage structure fully integrating the next generation wing and main landing gear concept	6.6.3	2020	37
Large Passenger Aircraft	Next Generation Cockpit & Avionic Concepts and	Integrated systems and avionics demonstration	Full 4D - flight capability; fully parameterized green trajectory capability	6.7.5	2020	38

<u>IADP / ITD</u>	<u>Technology Areas</u>	<u>Demonstrator / Technology Stream</u>	<u>Technologies</u>	<u>Reference Chapter</u>	<u>Complete by</u>	<u>ROM EC funding (in M€)</u>
	Functions for Large Passenger Aircraft	Next Generation Cockpit ground demonstrator	Development and validation suite for: - New MMI functions - Advanced IMA's - Networked data link and functions Fully integrated next generation avionics simulation & test lab	6.7.5	2020	19
		Flight demonstration Next Generation Cockpit & flight operation features	Cockpit feature flight demonstrator – Coordinated with Systems and Equipment ITD	6.7.4	2020	34
		"Pilot case" demonstration in flight	Qualification and validation of next generation cockpit features sensible to a highly realistic environment	6.7.6	2020	5
		service operations enhancement demonstrator	Demonstration of the technical and economic maturity and performance of a value and service oriented architecture and its enablers:	6.7.7	2020	15
Large Passenger Aircraft	Other [not for evaluation]		Other research activities and management: Included in Demonstrator Programmes.			0
Large Passenger Aircraft					Total:	521

<u>IADP / ITD</u>	<u>Technology Areas</u>	<u>Demonstrator / Technology Stream</u>	<u>Technologies</u>	<u>Reference Chapter</u>	<u>Complete by</u>	<u>ROM EC funding (in M€)</u>
Regional Aircraft	Highly Efficient Low Noise Wing Design for Regional Aircraft	Air Vehicle Technologies – Flying Test Bed#1 (FTB1)	Low noise and high efficient HLD, NLF, Active LC&A, Innovative wing structure and systems	7.5.3 (I) 7.5.2 (I) 7.5.2 (III) 7.5.2 (IV)	2021	22
Regional Aircraft	Innovative Passenger Cabin Design & Manufacturing for Regional Aircraft	Full scale innovative Fuselage and passenger Cabin	– Advanced High-toughness materials – Highly integrated structural concepts – SHM for damage detection and condition based maintenance – Advanced low-cost manufacturing – Highly automated assembly – Human centered cabin design – All electric/smart Systems integration	7.5.2 (III) 7.5.3 (II)	2021	31
Regional Aircraft	Advanced for Regional Aircraft: 1. Power Plant 2. Flight Simulator 3. Iron Bird	WTT for Configuration of Next Generation Hi-Efficient Regional A/C	Innovative configuration, advanced powerplant integration, efficient technologies insertion at A/C level	7.5.1	2020	6
		Flight Simulator	New cockpit interaction concepts, advanced avionics functionalities (including pilot workload reduction) , MTM (green functions in a global environment)	7.5.3 (III) 7.5.2 (II)	2020	6
		Iron Bird	Innovative systems integration, Next generation flight control systems (H/W and pilot in the loop)	7.5.3 (IV) 7.5.2 (III) 7.5.2 (IV)	2020	12

<u>IADP / ITD</u>	<u>Technology Areas</u>	<u>Demonstrator / Technology Stream</u>	<u>Technologies</u>	<u>Reference Chapter</u>	<u>Complete by</u>	<u>ROM EC funding (in M€)</u>
Regional Aircraft	Innovative Future Turboprop Technologies for Regional Aircraft	High Lift Advanced Turboprop – Flying Test Bed#2 (FTB2)	– Active Wing – Adaptive Aerodynamics, including Morphing Winglets – Wing related Systems integration – Advanced CFRP Wing structures – Optimized Powerplant integration	7.5.3 (V) 7.5.2	2017 - 2020	23
Regional Aircraft		Linked to all the above Regional Aircraft Demonstrators	Other research activities and management: – R-IADP Management (WP 0) – Technologies Development & Demonstrations Results Assessment (WP4), including interfaces with TE and Eco-Design transverse activity	7.4.2 7.5.4	2022	5
Regional Aircraft					Total:	104

<u>IADP / ITD</u>	<u>Technology Areas</u>	<u>Demonstrator / Technology Stream</u>	<u>Technologies</u>	<u>Reference Chapter</u>	<u>Complete by</u>	<u>ROM EC funding (in M€)</u>
Fast Rotorcraft: Joint/Transverse activities	Technology Evaluation & Eco Transversal Technologies		Transverse activities relevant to both FRC demonstrators and management (WP0)	8.5.1		12
Fast Rotorcraft: Tiltrotor	Advanced Tilt Rotor Structural & Aeroacoustic Design	D1: Mock-up of major airframe sections and rotor D2: Tie-down helicopter (TDH) D3: NextGenCTR flight demonstrator (ground & flight)	• System design • Structural and dynamics modelling and analysis software • Advanced electrical system • Aerodynamics/aeroacoustics modelling and analysis • Prototyping technologies	8.4 (WP1.1)	D1: 2016 D2: 2018/2019 D3: 2019/2020	23
		D4: Prop-rotor components and assembly	• System design and integration • Structural and dynamics modelling and analysis software • Aerodynamics/aeroacoustics modelling and analysis • Wind tunnel testing	8.4 (WP1.2)	2018/2019	11

<u>IADP / ITD</u>	<u>Technology Areas</u>	<u>Demonstrator / Technology Stream</u>	<u>Technologies</u>	<u>Reference Chapter</u>	<u>Complete by</u>	<u>ROM EC funding (in M€)</u>
Fast Rotorcraft: Tiltrotor	Advanced Tilt Rotor Aerodynamics and Flight Physics Design	D6: NextGenCTR's fuselage assembly	– Aerodynamics modelling and analysis – Structure modelling, analysis, testing – Advanced composite, metallic materials – Complex system design modelling and analysis – Design-to cost criteria – Design-to weight criteria	8.4 (WP1.4) 9.6.4 (Airframe ITD – WPB-4.2)	2018/2019	(22 M€ funding is part of Airframe ITD)
		D7: NextGenCTR's wing assembly	– Aerodynamics modelling and analysis – Structure modelling, analysis, testing – Advanced composite, metallic materials – Complex system design modelling and analysis – Design-to cost criteria – Design-to weight criteria	8.4 (WP1.4)	2018/2019	12
		D8: Engine-airframe physical integration D9: Fuel system components	– Aerodynamics modelling and analysis – Advanced system modelling, simulation and integration – Testing techniques	8.4 (WP1.5)	2018/2019	9
Fast Rotorcraft: Tiltrotor	Advanced Tilt Rotor Energy Management System Architectures	D5: NextGenCTR's drive system components and assembly	– Advanced materials for low environmental impact – Design-to cost criteria – Design-to weight criteria – Safe operation for “no-oil” emergency	8.4 (WP1.3)	2018/2019	10

<u>IADP / ITD</u>	<u>Technology Areas</u>	<u>Demonstrator / Technology Stream</u>	<u>Technologies</u>	<u>Reference Chapter</u>	<u>Complete by</u>	<u>ROM EC funding (in M€)</u>
		D10: intelligent electrical power system and ancillary/ auxiliary components D11: Flight control & actuation systems and components	– High–speed brushless generators – Solid statepower conversion and switching units – Advanced energy management architectures – Smart actuation systems – Advanced sensors and inceptors	8.4 (WP1.6)	2018/2019	22
Fast Rotorcraft: Tiltrotor	Technology Evaluation & Eco Transversal Technologies		Other research activities and management (including support to TE Impact Evaluator):	8.4 (WP1.0 +WP1.7)	2024	3
Fast Rotorcraft: Tiltrotor					Total:	89

<u>IADP / ITD</u>	<u>Technology Areas</u>	<u>Demonstrator / Technology Stream</u>	<u>Technologies</u>	<u>Reference Chapter</u>	<u>Complete by</u>	<u>ROM EC funding (in M€)</u>
Fast Rotorcraft: Compound R/C	Innovative Rotorcraft Design Compound Airframe	Airframe structure & landing system NB: Wing and tail addressed in Airframe ITD dedicated WPs (1.8, 1.11)	Advanced composite or hybrid metallic/composite structure using latest design and production techniques e.g. topological optimization, fibre/tape placement, out of autoclave curing, targeting very low weight and accommodating required cabin volume with low drag shape and wide access door for versatile usage (pax, SAR, EMS); Specific landing system architecture & kinematics suited for compound R/C configuration, using composite materials for weight reduction, electrically actuated. Environment-friendly materials and production techniques	8.7.11 8.7.12	2020	17

<u>IADP / ITD</u>	<u>Technology Areas</u>	<u>Demonstrator / Technology Stream</u>	<u>Technologies</u>	<u>Reference Chapter</u>	<u>Complete by</u>	<u>ROM EC funding (in M€)</u>
Fast Rotorcraft: Compound R/C	Innovative Compound Rotorcraft Power Plant Design	Lifting Rotor & Propellers	Integrated design of hub cap, blades sleeves, pylon fairings, optimized for drag reduction; Rotor blade design for combined hover-high speed flight envelope and variable RPM; Propeller design optimized for best dual function trade-off (yaw control, propulsion); All optimized for best mission performance and noise reduction with provision for icing protection capability, based on extensive use of state-of-art CFD and coupled CFD-CSD tools.	8.7.13 8.7.14	2020	6
		Drive train & Power Plant	Engine installation optimized for power loss reduction, low weight, low aerodynamic drag, all weather operation; New mechanical architecture for high speed shafts, Main Gear Box input gears, lateral shafts, Propeller Gear boxes, optimized for high torque capability, long life, low weight. REACH-compliant materials and surface treatments.	8.7.15 8.7.16	2020	22

<u>IADP / ITD</u>	<u>Technology Areas</u>	<u>Demonstrator / Technology Stream</u>	<u>Technologies</u>	<u>Reference Chapter</u>	<u>Complete by</u>	<u>ROM EC funding (in M€)</u>
Fast Rotorcraft: Compound R/C	Innovative Compound Rotorcraft Avionics, Utilities & Flight Control Systems	On board energy, cabin & mission systems	Implementation of innovative electrical generation & conversion, high voltage network, optimized for efficiency & low weight; advanced cabin insulation & ECS for acoustic and thermal comfort.	8.7.17 8.7.20	2020	10
		Flight Control, Guidance & Navigation Systems	Smart flight control exploiting additional control degrees of freedom for best vehicle aerodynamic efficiency and for noise impact reduction.	8.7.18 8.7.19 8.7.21	2020	13
Fast Rotorcraft: Compound R/C	LifeRCraft Flight Demonstrator	LifeRCraft Flight Demonstrator	Integration of all technologies on a unique large scale flight demonstrator, success & compliance with objectives validated through extensive range of ground & flight tests	8.7.10 8.7.22	2020	21
Fast Rotorcraft: Compound R/C					Total:	89

<u>IADP / ITD</u>	<u>Technology Areas</u>	<u>Demonstrator / Technology Stream</u>	<u>Technologies</u>	<u>Reference Chapter</u>	<u>Complete by</u>	<u>ROM EC funding (in M€)</u>
Airframe	High Performance and Energy Efficiency	Innovative Aircraft Architecture	Noise shielding, noise reduction, Overall Aircraft Design (OAD) optimisation, efficient air inlet, CROR integration, new certification process, advanced modeling	9.6.1	TRL 6: 2020	38
		Advanced Laminarity	Laminar nacelle, flow control for engine pylons, NLF, advanced CFD, aerodynamic flow control, manufacturing and assembly technologies, accurate transition modelling, optimum shape design, HLF	9.6.2	TRL 6: 2017 for further IADP testing	43
		High Speed Airframe	Composites (D&M), steering, wing / fuselage integration, Gust Load Alleviation, flutter control, innovative shape and structure for fuselage and cockpit, eco-efficient materials and processes	9.6.3	TRL 4/5: 2020	59
		Novel Control	Gust Load Alleviation, flutter control, morphing, smart mechanism, mechanical structure, actuation, control algorithm	9.6.4	TRL 5/6: 2019	12
		Novel Travel Experience	Ergonomics, cabin noise reduction, seats & crash protection, eco-friendly materials, human centered design, light weight furniture, smart galley	9.6.5	TRL 6: 2020	11

<u>IADP / ITD</u>	<u>Technology Areas</u>	<u>Demonstrator / Technology Stream</u>	<u>Technologies</u>	<u>Reference Chapter</u>	<u>Complete by</u>	<u>ROM EC funding (in M€)</u>
Airframe	High Versatility and Cost Efficiency	Next Generation Optimized Wing Box	Composite (D&M), out of autoclave process, modern thermoplastics, wing aero-shape optimisation, morphing, advanced coatings, flow and load control, low cost and high rate production	9.7.1	TRL 5: 2018 for further IADP testing TRL 6: 2020	31
		Optimized High Lift Configurations	Tprop integration on high wing, optimised nacelle shape, high integration of Tprop nacelle (composite/metallic), high lift wing devices, active load protection	9.7.2	TRL 5: 2018 for further IADP testing	23
		Advanced Integrated Structures	Highly integrated cockpit structure (composite metallic, multifunctional materials), all electrical wing, electrical anti-ice for nacelle, integration of systems in nacelle, materials and manufacturing process, affordable small aircraft manufacturing, small a/c systems integration	9.7.3	TRL 5: 2018 for further IADP testing TRL 6: 2020	51
		Advanced Fuselage	Rotor-less tail for fast r/c (CFD optimisation, flow control, structural design), pressurised fuselage for fast r/c, more affordable composite fuselage, affordable and low weight cabin	9.7.4	TRL 5: 2018 for further IADP testing	68

<u>IADP / ITD</u>	<u>Technology Areas</u>	<u>Demonstrator / Technology Stream</u>	<u>Technologies</u>	<u>Reference Chapter</u>	<u>Complete by</u>	<u>ROM EC funding (in M€)</u>
Airframe	Management and interfacing	Business jet, LPA, SAT, Rotorcraft and Regional a/c OAD and configuration	n/a	9.5	2020	10
Airframe					Total:	347
Engines	Innovative Open Rotor Engine Configurations	Open Rotor Flight Test	Ground test and flight test of a Geared Open Rotor demonstrator: - Studies and design of engine and control system update and modifications for final flight test - Manufacturing, procurement and engine assembly for ground test checking before flight Following on flight test planned in LPA IADP and test results analysis	10.5.1 10.6.1 10.7.1	TRL 6 (2019)	<i>Included in LPA IADP figures</i>
Engines	Innovative High Bypass Ratio Engine Configurations I : UHPE Concept for Short/Medium Range aircraft (Safran)	UHPE demonstrator	Design, development and ground tests of a propulsion system demonstrator for an Ultra High By-pass Ratio engine: validation of the low pressure modules and nacelle technology	10.5.2 10.6.2 10.7.2	TRL 5 (2022)	77
Engines	Business Aviation/Short Range Regional Turboprop Demonstrator	Business aviation/short range regional Turboprop Demonstrator	Design, development and ground testing of a new turboprop engine demonstrator for business aviation and short range regional application	10.5.3 10.6.3 10.7.3	TRL5/6 (2019)	22

<u>IADP / ITD</u>	<u>Technology Areas</u>	<u>Demonstrator / Technology Stream</u>	<u>Technologies</u>	<u>Reference Chapter</u>	<u>Complete by</u>	<u>ROM EC funding (in M€)</u>
Engines	Advanced Geared Engine Configuration	Advanced Geared Engine Configuration (HPC and LPT technology demonstration)	Design, development and ground testing of an advanced geared engine demonstrator: improvement of the thermodynamic cycle efficiency and noise reduction	10.5.4 10.6.4 10.7.4	Engine Demo 2020	44
Engines	Innovative High Bypass Ratio Engine Configurations II: VHBR Middle of Market Turbofan Technology (Rolls-Royce)	VHBR Middle of Market Turbofan Technology	– behaviour of fans at low speeds and fan pressure ratios (e.g. fan stall margin, variable cold nozzle geometries) and structural technology – aerodynamic and structural design of low pressure turbines for high speed operation – Systems Integration of novel accessory and power gearboxes, including oil system and bearing technologies. – optimised power plant (e.g integration of engine and nacelle structures, externals and dressings, Noise, Logistic & Build challenges) – compressor efficiency – control & electrical power system technology developments	10.5.5 10.6.5 10.7.5	TRL 4/5 2018	46

<u>IADP / ITD</u>	<u>Technology Areas</u>	<u>Demonstrator / Technology Stream</u>	<u>Technologies</u>	<u>Reference Chapter</u>	<u>Complete by</u>	<u>ROM EC funding (in M€)</u>
Engines	Innovative High Bypass Ratio Engine Configurations III: VHBR engine demonstrator for the large engine market (Rolls-Royce)	VHBR engine demonstrator for the large engine market	– integrated low pressure system for a high power very-high bypass ratio engine (fan, compressor, gearbox, LP turbine, VAN) – engine core optimisation and integration – optimised control systems – ground and flight test of Large VHBR engine	10.5.6 10.6.6 10.7.6	Engine Demo 2017-2019	69
Engines	Small Aircraft Engine Demonstrator	Small Aircraft Engine Demonstrator	– reliable and more efficient operation of small turbine engines – light weight and fuel efficient diesel engines	12.4.2		18
Engines	[Not for evaluation]		Other research activities and management: Budget for activities performed by airframer (Airbus) and for Eco-Design Transverse Activity			14
Engines					Total:	290

<u>IADP / ITD</u>	<u>Technology Areas</u>	<u>Demonstrator / Technology Stream</u>	<u>Technologies</u>	<u>Reference Chapter</u>	<u>Complete by</u>	<u>ROM EC funding (in M€)</u>
Systems	Integrated Cockpit Environment for New Functions & Operations	Extended Cockpit Demonstrations	– Flight Management evolutions : green technologies, SESAR, NextGen, interactive FM – Advanced functions : communications, surveillance, systems management, mission management – Cockpit Display Systems: new cockpit, HMI, EVO, etc. – IMA platform and networks	11.6.1 11.6.2 11.6.7 (I)	– TRL 5/6 in 2015 – TRL 5/6 in 2018+	58
Systems	Innovative and Integrated Electrical Wing Architecture and Components	Innovative Electrical Wing Demonstrator (including ice protection)	– New actuation architectures and concepts for new wing concepts – High integration of actuators into wing structure and EWIS constraints – Inertial sensors, drive & control electronics – New sensors concepts – Health monitoring functions, DOP – WIPS concepts for new wing architectures – Shared Power electronics and electrical power management – Optimization of ice protection technologies and control strategy	11.6.3	TRL 5 to 6 between 2018 to 2020+	32

<u>IADP / ITD</u>	<u>Technology Areas</u>	<u>Demonstrator / Technology Stream</u>	<u>Technologies</u>	<u>Reference Chapter</u>	<u>Complete by</u>	<u>ROM EC funding (in M€)</u>
Systems	Innovative Technologies and Optimized Architecture for Landing Gears	Advanced systems for nose and main landing gears applications	– Wing Gear and Body Gear configurations – Health Monitoring – Optimized cooling technologies for brakes – Green taxiing – Full electrical landing gear system for NLG and MLG applications – EHA and EMA technologies – Electro-Hydraulic Power Packs – Remote Electronics, shared PE modules – Innovative Drive & Control Electronics	11.6.4	TRL 4 to 6 between 2018 & 2020	30
Systems	High Power Electrical and Conversion Architectures	Non propulsive energy generation	– AC and DC electrical power generation – AC and DC electrical power conversion – SG design for high availability of electrical network – Integrated motor technologies, with high speed rotation and high temperature material	11.6.5 (I) 11.6.5 (III)	TRL6: 2020	27
		Equipments and Systems for new aircraft generations	Electrical motors for loads applications	11.6.6 (II)	TRL 4 to 5 between 2019 & 2020	9

<u>IADP / ITD</u>	<u>Technology Areas</u>	<u>Demonstrator / Technology Stream</u>	<u>Technologies</u>	<u>Reference Chapter</u>	<u>Complete by</u>	<u>ROM EC funding (in M€)</u>
Systems	Innovative Energy Management Systems Architectures	Innovative power distribution systems, (including power management)	– Electrical Power Centre for Large Aircraft – load management and trans-ATA optimization – High integrated power center for bizjet aircraft (multi ATA load management, power distribution and motor control) – Smart grid, develop & integrate breakthrough components to create a decentralized smart grid, partly in non-pressurized zone. – Electrical Power Centre – load management optimization – Health Monitoring, DOP compliant	11.6.5 (II)	TRL 5 & 6: from 2018 to 2020+	33
Systems	Innovative Technologies for Environmental Control System	Next Generation EECS, Thermal management and cabin comfort	– New generation of EECS including a global trans ATA visionable to answer the needs for load management, Inerting systems, Thermal Management, Air quality & cabin comfort – Development / optimisation of Regional A/C EECS components for full scale performance demonstration – New generation of cooling systems for additional needs of cooling	11.6.6 (I)	TRL 5 & 6: from 2018 to 2020+	26

<u>IADP / ITD</u>	<u>Technology Areas</u>	<u>Demonstrator / Technology Stream</u>	<u>Technologies</u>	<u>Reference Chapter</u>	<u>Complete by</u>	<u>ROM EC funding (in M€)</u>
Systems	Advanced Demonstrations Platform Design & Integration	Demonstration Platform – PROVEN, GETI & COPPER Bird®	– Use to mature technologies, concepts and architectures developed in Clean Sky 2 or from other R&T programs and integrated in Clean Sky 2 – Large demonstration platform – Optimization and validation of the thermal and electrical management between the main electrical consumers	11.6.7 (II) 11.6.7 (III) 11.6.7 (IV)	Large test platform to reach higher TRL level for electrical equipment / systems (from 4 to 6 depending of the application)	6

<u>IADP / ITD</u>	<u>Technology Areas</u>	<u>Demonstrator / Technology Stream</u>	<u>Technologies</u>	<u>Reference Chapter</u>	<u>Complete by</u>	<u>ROM EC funding (in M€)</u>
Systems	Small Air Transport (SAT) Innovative Systems Solutions	Small Air Transport (SAT) Activities	– Efficient operation of small aircraft with affordable health monitoring systems – More electric/electronic technologies for small aircraft – Fly-by-wire architecture for small aircraft – Affordable SESAR operation, modern cockpit and avionic solutions for small a/c – Comfortable and safe cabin for small aircraft Note: budget has been identified for specific SAT work inside Systems. However, synergies with main demonstrators and specific work still have to be worked upon	12.4.3		20
Systems	ECO Design	ECO Design activities	Refers to ECO Design chapter	ECO Design		5
Systems					Total:	246

<u>IADP / ITD</u>	<u>Technology Areas</u>	<u>Demonstrator / Technology Stream</u>	<u>Technologies</u>	<u>Reference Chapter</u>	<u>Complete by</u>	<u>ROM EC funding</u>
Technology Evaluator (TE)	A systematic overall approach to the Technology Evaluation process and monitoring activity		– Progress Monitoring of Clean Sky 2 achievements – Evaluation at Mission Level of particular ITD outputs – Impact Assessments at Airport and ATS Level The funding required for the Technology Evaluator will be taken from the Total Clean Sky 2 EC funding as a “tax in advance”.	12		17
JU Running Costs			The funding required for the running costs of the <i>Clean Sky 2</i> Joint Undertaking will be taken from the Total <i>Clean Sky 2</i> EC funding as a “tax in advance”.			39
Total CS2 EC funding:						1.755

<u>IADP / ITD</u>	<u>Technology Areas</u>	<u>Technologies</u>	<u>Reference Chapter</u>
Eco-Design Transverse Activity	An overall innovative approach and "agenda" for Eco-Design activity in the CS2 Programme	Eco-Design activities are embedded in all IADPs and ITDs. They are detailed in Chapter 13. Thus, a dedicated funding for Eco-Design is reserved inside each IADP's and ITD's funding. The co-ordination of all Eco-Design activities will be established in the Airframe ITD. The funding dedicated to the Eco-Design Transverse Activity is 39.06 M€ in total.	13
Small Air Transport (SAT) Transverse Activity	An overall innovative approach and "agenda" for Small Air Transport activity in the CS2 Programme	Small Air Transport (SAT) activities are part of Airframe, Engines (WP7) and Systems ITDs and are detailed in Chapter 14. The co-ordination of all SAT activities will be established in the Airframe ITD. The funding required for the Small Air Transport Transverse Activity is 67.95 M€ in total.	14

9. CLEAN SKY 2 PROGRAMME IMPLEMENTATION 2014 - 2015

The following chapter presents the Clean Sky 2 Programme scope of work and the main activities to be performed in the period 2014-2015⁶.

9.1. IADP LARGE PASSENGER AIRCRAFT

The Large Passenger Aircraft IADP approach builds on the positive experience in Smart Fixed Wing Aircraft (SFWA) in *Clean Sky*. The BLADE laminar wing flight test demonstrator, the CROR demo engine flying test-bed and two different low speed and load control flight tests under preparation will provide unique contributions towards maturing technologies for application in the next generations of aircraft. For *Clean Sky 2*, the Large Passenger Aircraft goal is a high-TRL demonstration of the best candidates to accomplish the combined key ACARE goals with respect to the environment, fulfilling future market needs and improving the competitiveness of future products. The encompassed environmental goals are to achieve substantial double digit fuel burn efficiency at aircraft level, an end to end product life cycle that requires a greatly reduced amount of energy and resources and a significant reduction of the community noise. Reaching a significant reduction of community noise at the best level of economic efficiency is one of the biggest challenges, as the optimisation towards both targets typically leads to divergent solutions. Facing this challenge shall be part of the technology development and demonstration in LPA platform 1.

The setup of the main programme objectives is to further push the value of technologies tackled in *Clean Sky*. The focus is on large-scale demonstration of technologies integrated at aircraft level in 3 distinct ‘Platforms’:

- Platform 1: “Advanced Engine and Aircraft Configurations” will provide the development environment for the integration of the most fuel efficient propulsion concepts into the airframe targeting next generation short and medium range aircraft, the CROR engine and the Ultra-High Bypass Ratio (UHBR) turbofan;
- Platform 2: “Innovative Physical Integration Cabin – System – Structure” is aiming to develop, mature, and demonstrate an entirely new, advanced fuselage structural concept developed in full alignment towards a next generation of cabin-cargo architecture, including all relevant principle aircraft systems;
- Platform 3: “Next Generation Aircraft Systems, Cockpit and Avionics” has a clear focus to develop and demonstrate a next generation cockpit and navigation suite. Based on the results of a number of research programmes which are currently on-going or to be started shortly, platform 3 shall provide the programme to integrate and validate all functions and features which are emerging from individual developments into a new concept, in a major demonstrator suite. Added to the platform an advanced systems maintenance activity.

⁶ The list of deliverables and milestones presented in this chapter is a provisional and may be updated at the stage of the preparation and signature of the Grant Agreement for the Members.

Description of activities in 2014 and 2015

The LPA activities in 2014 are focused to launch activities in all three platforms, *Platform 1 “Advanced Engine and Aircraft Configuration*, *Platform 2 “Innovative Physical Integration Cabin, System and Structure”* and *Platform 3 “Next generation aircraft systems, cockpit systems and avionics”*.

Platform 1

In the following description of LPA Platform 1, three areas of proposed work during 2014-15 are related to activities that are yet to conclude a successful technical evaluation. As such, funding for these activities and their inclusion is subject to a positive outcome of the evaluation (scheduled for May 2014). These areas are the following areas: Innovative Flight Operations, Advanced Propulsion Systems and Innovative Aircraft Configuration Demonstrator.

In Platform 1, the priority is to implement and launch all activities related to the development of the CROR flight test demonstrator, based on the latest possible results and outcome from the SFWA-ITD in *Clean Sky*, adjusted to the key milestones of the CROR ground demonstrator engine in SAGE 2. The work will focus on the engine integration (flight-worthy engine) into the overall aircraft, the associated thermal management, static and dynamic loads transfer as well as the preparation of the flight-test demonstrator. Any additional work required for achieving the economic viability, such as weight reduction efforts and the demonstration of the aerodynamic and acoustic performance of the integrated engine will be performed in the Airframe ITD. A specific work package starting in 2014 is associated to the non-propulsive energy generation systems architectures of advanced engine concepts with a principle elaboration of the requirements.

Further priorities in Platform 1 will be the launch of activities for the advanced engine integration driven fuselage demonstrator, which is a key contributor to develop and proof the viability of an aircraft configuration with a CROR propulsion system integrated at the rear of the aircraft. A suite of associated technologies will be developed and matured in a fully coherent, combined approach to provide key elements to demonstrate and validate the prospected added values of the CROR engine integrated into a next generation large passenger aircraft. Major activities are the start of the principle design and the compilation of the project development plan for rear end integration.

A further work package in Platform 1 is the systematic proof of scaled flight testing as viable means to mature and validate new aircraft technologies and aircraft configurations to high levels of technology readiness and the representativeness of the results for full-scale vehicles. This includes the evaluation of the reliability and quality of this mean, including the definition of a principle set of standard rules and procedures for all contributing elements as well as the quality of the equipment and measurement instrumentation. Also the basic requirements for the entire testing environment such as test platform, type of test range, data acquisition, etc. will be specified.

The HLFC technology status for the CS2 LPA objectives based on the progress achieved in running projects at EU and national level, such as AFLoNext and HIGHER-LE, will be reviewed and adopted in a first phase. Subsequently, the development and manufacturing of an improved HLFC fin-demonstrator for long-term in-service operational use will be started. In parallel to that, the definition of rules and processes required for certification for in-service long term demonstration and deployment of the HLFC technology at major components of the airframe will be launched. This will be done in close alignment with the relevant “Extended Laminarity” work packages in the Airframe ITD.

Under enabling technologies for improved aircraft performance the target is to further industrialize active flow control technologies to enable the integration of Ultra-High Bypass Ratio (UHBR) engines. The plan is to integrate active flow control technology in the wing/pylon junction to delay or even prevent flow separation on the wing, which is one of the root causes of reduced take-off performance of the aircraft. The supporting technology development on component level will be performed in the work packages of the “Next generation optimized wing box” in the Airframe ITD.

For the benefit of next generation civil transport aircraft, concepts will be developed comprising of an airframe design with associated propulsion technology architecture, such as a novel hybrid propulsion power chain. A further objective is to integrate and demonstrate UHBR engine technology for future long-range aircrafts. Linked to these objectives well-suited testing strategies and testing processes will be developed. The preliminary architectural work for engine integration will be performed in the relevant work packages of the Engines ITD.

The demonstrator activities in Platform 1 have various links to the ITDs. The links are planned to survive throughout most of the project lifetime, with a synchronization of R&T along the readiness level of the relevant technologies in the ITD respectively the IADP.

Platform 2

The activities in 2014 will mainly focus on the compilation of requirements and functions that the integrated concept is expected to fulfil, as well as defining a lean process for cascading them down to sub-components, modules or elementary parts. A first study on disruptive architecture configurations will be conducted as well as several screenings on needed building blocks, such as interface technologies, materials and development processes.

Keeping in mind the objectives of the platform, the effect of requirements on key parameters will start to be analysed and challenged in order to move towards an innovative overall optimisation. For example, highly integrative approaches can lead to changes with respect to customisation compared to the state of the art solution. It could affect the visible cabin area as well as the installations covered behind linings and which define functionality, e.g. electrical network architecture, routing and manufacturing.

A particular share of work to start in 2014 will be related to the definition of requirements to alleviate the current certification procedures and constraints and to challenge the number and duplications of design rules and requirements. This work will start in collaboration with partners and certification authorities and will aim to tackle a wide scope of domains in order to identify arbitrary rules. A review and redefinition in specification, design and certification

rules with respect to a future “cross ATA” design is a key element of this work. In 2015, the specification of the Platform 2 target integrated demonstrators will start. It is expected that inputs from Core-Partners selected through wave 1, and to a lesser extent wave 2, will lead to gradual updates of the Work Plan during 2015. Links to the *Clean Sky 2* ITDs will be established to include technology modules for the innovative cabin. These links will also integrate systems relevant for the development of the integrated next generation fuselage-cabin and cargo Systems integrated concept from the early stages of the project at least until the critical design review of the demonstrators.

In 2015 the Platform 2 will also focus on the development and manufacturing of cabin & cargo functional elements within the cabin & cargo perimeter as enabler for weight savings, reduced production costs, operational efficiency, ancillary revenue and comfort. Specific areas of research shall be:

- A moveable Passenger Service Unit satellite;
- The development of fuel cell technologies for decentralised power supply systems, e.g. for galleys;
- Onboard Inert Gas Generation System (OBIGGS) able to perpetuate nitrogen enriched air as part of a halon-free, environmentally friendly cargo fire suppression system.

Platform 3 (under revision)

The content of the platform will be described at the end of the revision by the JU of the platform. No activity is planned at the beginning of CS2, except the maintenance part (which has passed successfully the evaluation). We propose to address advanced system maintenance, including features of integrated health management and monitoring, service oriented architectures and enhanced maintenance execution capabilities. Similar to the research and development activities planned towards a new fully integrated fuselage- cabin and cargo structure and system approach in platform 2, it is expected to derive explicit eco-design relevant benefits, e.g. through fewer scheduled routine maintenance or overhaul actions.

Major milestones planned for 2014:

Platform 1

- Identification of Core-Partners, first wave

Platform 2

- Identification of Core-Partners, first wave

Platform 3

- Initiation of the maintenance work package architecture definition

Major deliverables planned for 2014:

Platform 1

- Architecture dossier for flight test demonstrator-vehicle selection
- Analysis report of expected scope and constraints for scaled flight testing for Large Passenger Aircraft and associated testing approaches, (1st issue)

Platform 2

- Next generation fuselage architecture dossier, requirements and functionalities (1st issue)
- Definition of concepts for new Cabin & Cargo architecture

Platform 3

- Maintenance architectural concepts definition
- Identification of platforms for maintenance demonstrations

Major milestones planned for 2015:

Platform 1

- Engagement of Core-Partners, first wave update of associate sections of the work plan
- Identification of Call for proposal Partners, first call
- Identification of Core-Partners, second wave
- Endorsement of updated Project Development Plan for CROR FTD, including economic viability gates
- Compilation of the Project Development Plan for the rear-end demonstrator
- Confirmation of the target design and manufacturing process for the HLFC nose applied on vertical tailplane based on results of AFLoNext, HIGHER-LE and incorporated requirements from CS2 (long-term testing, operational readiness).
- Definition of certification rules and procedures for flight test with full scale HLFC fin.

Platform 2

- Engagement of Core-Partners from the first wave and update of the work plan
- Engagement of Call for proposal Partners, first call
- Identification of Core-Partners, second wave

Platform 3

- Start of service oriented architecture definition and prognostic activities

Major deliverables planned for 2015:

Platform 1

- Project Development Plan for the rear-end demonstrator
- Project Development Plan for CROR FTD
- Dossier prepared about the initial technical definition of rear-end demonstrator.
- Dossier prepared about the technical content of CROR FTD
- Testing approach for scaled flight testing available and preparation of test platform software and flight control laws
- Dossier prepared about the target design and manufacturing process for the operational HLFC fin

Platform 2

- Detailed project development plan including all demonstrators and work shares for wave 1 and 2 Core Partners
- Next generation fuselage requirements and functionalities compilation dossier
- Recommendations on requirements, challenges and prioritization
- Next generation integrated fuselage candidate concepts /architectures (1st issue)

Platform 3

- Maintenance operations dossier

Note: The list of deliverables and milestones presented here is a provisional list and may be updated at the moment of the signature of the Grant Agreement for the Members.

Implementation

The activities in the Large Passenger Aircraft IADP will be performed following the general principles of the Clean Sky 2 membership and participation.

Airbus, as the IADP Leader, will perform the main activities related to the technology development and demonstration in the IADP. Significant part of the work will be performed by Core Partners, supporting the IADP leader in its activities. Finally, another part of the activities will be performed by Partners through Calls for Proposals for dedicated tasks.

Airbus, as the IADP Leader, will sign the one Grant Agreement for Members (GAM) in order to perform the work. This GAM will cover all the work of the Members in this IADP. The Core Partners are selected through open Calls for Core Partners and the retained applicants will accede to the existing Grant Agreement for Members. Partners will be beneficiaries selected at a later stage on the basis of open Calls for Proposals and will be signing the Grant Agreement for Partners. They will be linked to the IADP activities through the Coordination Agreement.

The following topics are opened for the first call for Core Partners:

JTI-CS2-2014-CPW01-LPA	
JTI-CS2-2014-CPW01-LPA-01-01	Advanced Engine and Aircraft Configurations Strategic complementary research to prepare, develop and conduct large scale demonstration
JTI-CS2-2014-CPW01-LPA-01-02	Integrated Flow Control Applied to large Civil Aircraft
JTI-CS2-2014-CPW01-LPA-01-03	Advanced HLFC fin design work: Structural design and manufacturing of operational HLFC fin
JTI-CS2-2014-CPW01-LPA-01-04	Specific Design and Manufacturing of fuselage rear end and engine supports
JTI-CS2-2014-CPW01-LPA-01-05	PoWer Turbine of the flight demonstrator CROR engine
JTI-CS2-2014-CPW01-LPA-01-06	Rotating Frames of the flight demonstrator CROR engine
JTI-CS2-CPW01-LPA-02-01	Airframe Cabin and Cargo and System integration Architecture
JTI-CS2-CPW01-LPA-02-02	Cabin & Cargo Functional System and Operations

Detailed description of the topics is provided in ***Annex I - 1st Call for Core-Partners: List and Full Description of Strategic Topics***.

Type of action: [*Innovation action, funding rate 70%⁷*]

9.2. IADP REGIONAL AIRCRAFT

In *Clean Sky*, a dedicated ITD - Green Regional Aircraft (GRA) - provides essential building blocks towards an air transport system that respects the environment, ensures safe and seamless mobility and builds industrial leadership in Europe. In *Clean Sky 2*, the Regional Aircraft IADP will bring the integration of technologies to a further level of complexity and maturity than currently pursued in *Clean Sky*. Taking into account the outcomes of GRA and considering the high-level objectives derived from recent market analysis performed by the Leaders, the strategy is to integrate and validate, at aircraft level, advanced technologies for regional aircraft so as to drastically de-risk their integration on the following future products:

- Near/midterm (in-service from 2022-25on): Regional Aircraft with underwing mounted turboprop engines,
- Long term (enter in service beyond 2035): Breakthrough Regional Aircraft Configurations, e.g. a/c with rear fuselage mounted turboprop engines

The proposed demonstration programmes are:

- 2 Flying TestBeds (FTB), in the IADP, (to minimize the technical and programme risks) using modified existing regional turbo-prop aircraft with under-wing mounted engines, for demonstration campaigns; FTB#1 (Alenia Aermacchi) will mainly focus on the demonstration of technologies improving the cruise and climb performance, while FTB#2 (EADS-CASA) will be oriented to test technologies for Regional A/C optimized for short point to point flights, connecting airports with short runways in the middle of a city and pleiad of islands and, in general, towards more advanced high lift performances and more efficient configuration for climb and descending phases.
- 5 large integrated Ground Demonstrators: full-scale wing (Airframe ITD), full-scale cockpit (Airframe ITD), full-scale fuselage and cabin (IADP), flight simulator and iron bird (IADP).

Full scale demonstrations, with acceptable risk and complexity but still providing the requested integration, are essential to allow the insertion of validated technologies on future regional aircraft. The IADP Demonstration Programme will be divided into technologically compatible demonstrations sub-programmes:

- Innovative Wing and Flight Controls: integration and flight testing of technologies for a new generation wing and advanced flight control systems;
- Flight Demonstration of a highly efficient and low noise wing including structural aspects;

⁷ Research organisations may apply for the 100% funding rate in accordance with H2020 rules

- Full scale innovative fuselage and passenger cabin for increased passenger comfort and safety;
- Flight Simulator demonstrating new cockpit interaction concepts as well as advanced avionics;
- Virtual and Physical “Iron Birds” as part of the Regional A/C Ground Demonstration Programme.

Such a demonstration programme is very challenging and the first phase of the R-IADP project (time frame years 2014-2015) is of paramount importance since it will enable the detailed definition of all the necessary technical and management activities so as to ensure that through the project development the demonstrators objectives will be achieved as planned in the JTP and fully in accordance with the strategic objectives for regional aircraft mentioned in the above text.

In particular, the overall main objectives for the 2014-2015 period are:

- to select all the R-IADP Core Partners;
- to define the Preliminary Requirements for the Demonstration Program;
- to define the first loop of the Technological Waves Roadmaps for Demonstrators;
- to initialize the technical activities for WP1, WP2 and WP3

During the time frame 2014-2015, both R-IADP and GRA will be managed through an unique Integrated Risk Management Plan since the former follows on from and partly builds up on the results obtained by the latter, as per Council Regulation on the Clean Sky 2 Joint Undertaking dictate, allowing and contributing to the finalisation of research activities initiated under Regulation (EC) No 71/2008.

So as to ensure GRA mitigation actions plan becoming R-IADP recovery actions plan, without a smooth transition from CS to CS2 obligations.

Year 2014

Overview

During 2014, a more detailed definition of the technical activities, WBS (Work Packages Breakdown Structure) covering the complete R-IADP project, will performed. Obviously, this will be a preliminary version to be revised once Core Partners are selected and main program workstream is established. The technical activities will start in the following work packages / Sub-Work packages:

- WP1 – High Efficiency Regional A/C (sub-WPs 1.1, 1.2, 1.3)
- WP2 – Technologies Development (sub-WPs 2.1, 2.2, 2.3, 2.4)
- WP3 – Demonstrations (sub-WPs 3.1, 3.3, 3.4, 3.5)

Furthermore, the following technical transversal activities will be performed in 2014:

- Contribution to the strategic topics descriptions for the Core-Partners selection (1st wave)
- Negotiations with Core Partner Winners (1st Wave)

- Preliminary development of Waves technological roadmaps
- Initial Activities on Systems Engineering Technical Management in terms of Processes, Methods and Tools (definition and set-up).
- Contribution to the strategic topics descriptions for the Core-Partners selection (2nd wave)

WP0 – Management

Coordination, administration and management of technical activities assuring interactions and interfaces with the JU and other IAs; participation and preparation work to *Clean Sky 2* committees.

WP1 – High Efficiency Regional A/C

Preliminary studies of innovative turboprop aircraft configurations will be started. The activities will be based on two conceptual aircraft configurations. The first one will be a conventional turboprop architecture (underwing engine mounted as GRA TP90) that will be sized on the following parameters (preliminary):

- About 1000 - 1300 nm design mission
- 90 pax class
- Cruise speed $M = 0.52 - 0.55$ at 250 FL
- Ground performance as GRA TP90

The second conceptual aircraft will consist of a breakthrough regional aircraft configuration: Turboprop rear fuselage Engines installation.

Sizing of this conceptual a/c will be started on the basis of the following preliminary requirements:

- About 1500 - 2000 nm design mission
- 100 pax class (final pax number to be defined)
- Cruise speed $M > 0.60$ at 300-350 FL
- Ground performance (TBD)

A preliminary general market analysis will be performed in order to have, in the starting phase of the project, a first issue of Top Level Aircraft Requirements. A relevant figure will be defined on aspects regarding the definition of external and internal noise TLAR, in order to assess the reduction of noise footprint impact in airport areas and assess the technologies that increase the passenger comfort.

In order to enable the technologies studies of WP2, this work package will also provide initial targets to be applied to single technological aspects.

WP2 – Technologies

The activities of this work package will start with a review of the technologies developed in the current CS GRA Domains and in other EU projects. For each sub-work package a

roadmap will be defined and in synergy with other relevant ITDs, in particular Airframe ITD and Systems ITD.

To start the activities on the Adaptive Electric Wing, during 2014 a selection of reference A/C baseline configuration will be performed as a common working base for Technology Waves iterations. In parallel the evaluation criteria for first technologies down selection and the aerodynamic design procedure for NLF wing will be defined; relevant baseline existing Computer Aided Engineering (CAE) modelings for technologies scaling and assessments will be selected; procedures for concepts evaluation of Morphing Structures, High Lift Devices (HLD), Loads Control & Alleviation, Natural Laminar Flow (NLF) wing design, drag and noise reduction will be defined for technologies down selections. In particular, the effect of all investigated concepts will be evaluated in terms of effect on noise footprint reduction.

For the Wing Structure: i) preliminary architectural trade-offs will be performed; ii) manufacturing tools preliminary requirements will be defined and the set-up of processes for wing components realization will be started; iii) preliminary requirements will be defined for the Rational Engineering A/C Life Cycle methodologies for Core Partners involvement, leading to the high level description of objectives and requirements at A/C level.

For the Avionics Technologies development, the following activities will be performed: i) definition of preliminary Regional aircraft customization requirements for Display, FMS and avionic functions: ii) definition of preliminary requirements for Regional a/c Maintenance/Health Monitoring function.

For the On Board Systems, activities will start with a review and assessment of candidate Systems technologies to be developed for the “Energy Optimized Regional A/C” in the area of Wing Ice Protection System (WIPS), Electrical Landing Gear System (E-LGS), Thermal management (ThM), Advanced Electrical Power Generation and Distribution (A-EPGDS), Electrical Environmental Control System (E-ECS), Innovative Propeller, Enhanced Fuel/Inheriting System.

For the Flight Control System, preliminary architecture studies will be performed. They will be based on new actuation technologies (Electro-Mechanical Actuators), on innovative bus interconnection/data exchange and on leading-edge technology computing systems, considering certification targets.

For all the above systems, the activities will be performed in synergy with the Systems ITD. In particular, through proper interactions and interfaces with this ITD, the architectures evaluation and trade-off studies will be performed and technology roadmaps (objectives, process and sharing of responsibilities for technology Verification and Validation) will be defined.

WP3 – Demonstrations

Initial requirements for the Flight Demonstration Program as well as for the Iron Bird and Flight Simulator will be defined.

The requirements for the Flight Demonstration Program will be preliminarily defined in close cooperation between Alenia and EADS-CASA so as to maximize the synergies and cross-fertilization between the FTB#1 and FTB#2.

For the Iron Bird, which is linked to FTB#1 only, preliminary architecture will be performed, identifying the goals (TRL 5/6 achievement), the typology of testing and the configuration under test. Evolution capabilities shall be also considered. Preliminary requirements for the CS2 Regional Aircraft Flight Simulator will be defined.

Major milestones planned for 2014:

- M1 - Kick-off Meeting
- M2 - Selection of the first batch of Core Partners
- M3 - Initialization of Technology developments
- M4 - 2014 Year End Activities Review

Major deliverables planned for 2014:

WP0 – Management

- Contribution to the strategic topics descriptions for the Core-Partners selection (1st wave):
 - Development of advanced systems technologies and hardware/software for the Flight Simulator and Iron Bird ground demonstrators for regional aircraft
 - Advanced Wing for Regional A/C - Technologies Development, D&M for FTB1 (Alenia)
 - Flight Physics and wing integration in FTB#2 (EADS-CASA)
- R-IADP System Engineering and IT tools and methods – 1st issue (Alenia):
 - Preliminary System Engineering Management Plan (SEMP) with Quality and Convention Rules definition for Preliminary Design Phase
 - IT Tools and Methods Implementation Plan (Set up of Operative Model) for Preliminary Design Phase
- Preliminary Roadmaps for each Technological Wave (Alenia/EADS-CASA)

WP1 – High Efficiency Regional A/C

- Preliminary Top Level Aircraft Requirements (Alenia)
- High Efficiency Regional Aircraft - Preliminary design loop (Alenia)

WP2 – Technologies

- Morphing Structures and HLD Concepts Down-Selection Criteria (Alenia)
- Loads Control and Alleviation Devices Concepts Down-Selection Criteria (Alenia)
- NLF design and Drag reduction concepts Criteria (Alenia)
- Wing components Manufacturing tools preliminary requirements. (Alenia)
- Preliminary requirements of methodologies for Rational Engineering A/C Life Cycle. (Alenia)
- Preliminary customization requirements for Display, FMS and avionic functions (Alenia)

- Systems technologies trade-off analyses, preliminary Architecture, preliminary Verification and Validation Plan (Alenia)

WP3 – Demonstrations

- Preliminary Requirements for the Flight Demonstration Program (Alenia/EADS-CASA)
- Preliminary requirements for the flight simulator (Alenia)
- FCS preliminary architecture and Iron Bird concept document (Alenia)
- Roadmap for FTB#2 GLA/MLA concept and wing conceptual design(EADS-CASA)
- Identification of available technologies and TRL associated. Assessment of potential added value (EADS-CASA)

Year 2015

Overview

During 2015, the detailed definition of the technical activities, WBS (Work Packages Breakdown Structure) covering the complete R-IADP project, will be consolidated with the contribution of selected Core Partners. The technical activities will continue in the: WP0 – Management; WP1 – High Efficiency Regional A/C (sub-WPs 1.1, 1.2, 1.3); WP2 – Technologies Development (sub-WPs 2.1, 2.2, 2.3, 2.4) and WP3 – Demonstrations (sub-WPs 3.1, 3.2, 3.3, 3.4, 3.5). Within these Work Packages:

- Alenia will: continue the studies on the innovative turboprop aircraft configuration; scale to reference configuration wing technologies from current CS and SARISTU, assess the performance of concepts to gain information for first step of technology down selection; assess NLF wing aerodynamic design and in flight certification requirements investigation; define the wing structure conceptual design; consolidate the regional aircraft requirements for Systems; start the development of peculiar Regional avionic function: start the Flight Simulator update; consolidate system technologies roadmap and sharing of activities; define Systems technologies design requirement and architectures; preliminarily down select the functionalities/subsystems to be verified in FTB#1; preliminarily scale the FCS architecture and actuation concepts defined in 2014 on the target FTB#1; preliminarily define the Iron Bird considering the target FTB#1; start activities on Affordability/Preliminary Cost Analysis; define the external noise evaluation strategy and criteria for developed technologies assessment in terms of noise impact.
- EADS-CASA will: i) perform the necessary trade-offs to define the concept for the new wing, based on MDO approach; ii) define WTT activities and wing model; iii) start the definition of A/C controls including MLA/GLA; iii) Complement the detailed technical specifications for the systems and structural elements identified in ITD with potential extension into IADP.

Furthermore, the following technical transversal activities will continue in 2015:

- Contribution to the strategic topics descriptions for the Core-Partners selection (2nd wave) and CfPs (1st batch)
- Negotiations with Core-Partner Winners (2nd Wave) and Partners (1st batch)
- Definition of Waves technological roadmaps
- Activities on Systems Engineering Technical Management in terms of SE Processes, Methods and Tools definition and set-up.

Major milestones planned for 2015:

- M1 - Selection of Core Partners (2nd wave)
- M2 - Mid-Year Review Technology Assessments and Development progress
- M3 - 2015 Annual Review

Major deliverables planned for 2015:

WP0 – Management

- Contribution to the strategic topic descriptions for Core Partners Selection (2nd Wave) (Alenia):
 - FTB#1 Demonstration Aircraft (Alenia)
 - D&M of items for innovative fuselage/cabin demonstrator (Alenia)
 - Technological contributions to conceptual design of innovative regional aircraft configurations featuring advanced integration of powerplant (Alenia)
- R-IADP System Engineering and IT tools and methods – 2nd issue (Alenia):
 - System Engineering Management Plan (SEMP) with Quality and Configuration/Convention Rules for Definition and Detailed Design Phases. (Alenia)
 - IT Tools and Methods Implementation Plan (Set up of Operative Model) for Definition and Detailed Design Phases (Alenia)
- Consolidated Roadmaps for each Technological Wave (Alenia)

WP1 – High Efficiency Regional A/C

- Top Level Aircraft Requirements update (Alenia)
- High Efficiency Aircraft - First design loop (Alenia)

WP2 – Technologies

- Assessment preliminary results for Morphing Structures concepts for first step of technology down selection (Alenia)
- Qualification System Plan for Morphing Structures concepts (Alenia)
- Assessment of results for HLD concepts for first step of technology down selection (Alenia)
- Assessment of preliminary results for Loads Control and Alleviation concepts for first step of technology down selection (Alenia)
- Qualification System Plan for LC&A concepts (Alenia)

- Assessment of results for NLF design criteria (Alenia)
- Assessment of results for drag reduction concepts for first step of technology down selection (Alenia)
- Wing structure conceptual design (Alenia)
- Pilot fabrication facilities preliminary requirements for wing components manufacturing (Alenia)
- Requirements specifications of methodologies for Rational Engineering A/C Life Cycle (Alenia)
- Regional A/C customization requirements update for Display, FMS and avionic functions (Alenia)
- Systems Technologies Verification and Validation Plans (Alenia)
- Systems Technologies preliminary Integration Requirements (Alenia)
- Preliminary FCS architecture and actuation concepts on the target FTB#1 (Alenia)

WP3 – Demonstrations

- Progress report on CS2 Regional Flight Simulator update (Alenia)
- Iron Bird preliminary definition considering the target FTB#1 (Alenia)
- MLA/GLA preliminary architecture (EADS-CASA)
- Wing conceptual design and Wing WTT models. (EADS-CASA)

All the above 2015 deliverables will be confirmed at the end of 2014 results, upon Core-Partners selection.

Note: The list of deliverables and milestones presented here is a provisional list and may be updated at the moment of the signature of the Grant Agreement for the Members.

Implementation

The activities in the Regional Aircraft IADP will be performed following the general principles of the Clean Sky 2 membership and participation.

Alenia Aermacchi, as the IADP Leader, will perform the main activities related to the technology development and demonstration in the IADP. Significant part of the work will be performed by Core Partners, supporting the IADP leader in its activities. Finally, another part of the activities will be performed by Partners through Calls for Proposals for dedicated tasks.

Alenia Aermacchi, as the IADP Leader, will sign the one Grant Agreement for Members (GAM) in order to perform the work. This GAM will cover all the work of the Members in this IADP. The Core Partners are selected through open Calls for Core Partners and the retained applicants will accede to the existing Grant Agreement for Members. Partners will be selected at a later stage through Calls for Proposals and will be signing the Grant Agreement for Partners. They will be linked to the IADP activities through the Coordination Agreement.

The following topics are opened for the first call for Core Partners:

JTI-CS2-CPW01-REG	
JTI-CS2-2014-CPW01-REG-01-01	Development of advanced systems technologies and hardware/software for the Flight Simulator and Iron Bird ground demonstrators for regional aircraft
JTI-CS2-2014-CPW01-REG-01-02	Advanced wing for regional A/C - Technologies Development, Design and Manufacturing for FTB#1
JTI-CS2-2014-CPW01-REG-02-01	Flight Physics and wing integration in FTB2

Detailed description of the topics is provided in ***Annex I - 1st Call for Core-Partners: List and Full Description of Strategic Topics***

Type of action: *[Innovation action, funding rate 70%⁸]*

⁸ Research organisations may apply for the 100% funding rate in accordance with H2020 rules

9.3. IADP FAST ROTORCRAFT

The Fast Rotorcraft IADP of *Clean Sky 2* consists of two separate demonstrators, the *NextGenCTR tiltrotor* (leader: Agusta Westland) and the *LifeRCraft compound helicopter* (leader: Airbus Helicopters). These two fast rotorcraft concepts aim to deliver superior vehicle productivity and performance, and through this economic advantage to users.

NextGenCTR will be dedicated to design, build and fly an innovative next generation civil tiltrotor technology demonstrator, the configuration of which will go beyond current architectures of this type of aircraft. This tiltrotor concept will involve tilting proprotors mounted in fixed nacelles at the tips of relatively short wings. These wings will have a fixed inboard portion and a tilting outboard portion next to the nacelle. The tilting portion will move in coordination with the proprotors, to minimize rotor downwash impingement in hover and increase efficiency. Demonstration activities will aim at validating its architecture, technologies/systems and operational concepts. They will show significant improvement with respect to current Tiltrotors. NextGenCTR will continue to develop what has been initiated in Green Rotorcraft ITD in Clean Sky. New specific activities will also be launched in *Clean Sky 2* in particular concerning drag reduction of the proprotor, airframe fuselage and wing. The new proprotor will require substantial research to reduce noise emissions. In *Clean Sky*, noise reduction is mainly addressed through the optimisation of flight trajectories. In *Clean Sky 2* transversal subjects will cover new research areas, validating them at full scale and in real operational conditions.

The LifeRCraft project aims at demonstrating the compound rotorcraft configuration, implementing and combining cutting-edge technologies from the current *Clean Sky* programme, and opening up new mobility roles that neither conventional helicopters nor fixed wing aircraft can currently cover. The compound concept will involve the use of forward propulsion through turbo-shaft driven propellers on short wings, complementing the main rotor providing vertical lift and hover capability. A large scale flightworthy demonstrator, embodying the new European compound rotorcraft architecture, will be designed, integrated and flight tested. This demonstrator will allow reaching the TRL 6 at full-aircraft level in 2020. The individual technologies of the *Clean Sky* Programme (Green Rotorcraft, Systems for Green Operations and Eco-Design ITDs) aiming at reducing gas emission, noise impact and promoting a greener life cycle will be further matured and integrated in this LifeRCraft demonstration.

In 2014, the preliminary sizing and design of the two demonstrators (tiltrotor architecture, compound rotorcraft architecture) will be initiated by the IADP Leaders.

Description of activities 2014-2015

WP0 – Management and transversal activities

WP 0.0: Consortium Management. In 2014, the Leaders will jointly adapt the Clean Sky GRC ITD organization and common procedures to the new scope and framework of FRC IADP. Planning and reporting activities will be implemented in 2014 and 2015 as required for the regular monitoring of IADP activities, in liaison with the JU Officers.

WP 0.1: Technology Evaluator methodology for fast rotorcraft. In 2014, the IADP Leaders and the TE points of contact will jointly define SMART objectives and criteria adapted to the fast rotorcraft missions in line with the general TE approach for *Clean Sky 2*. In 2015, the tools used in GRC1-GRC7 will be adapted and further developed in order to enable the assessment of conceptual rotorcraft models corresponding to the new configurations to be demonstrated.

WP 0.2: Eco-Design concept implementation to fast rotorcraft. In 2014-2015, the leaders will coordinate their activity plans concerning the greening of rotorcraft production processes ensuring complementarity of case studies. The general Life Cycle Assessment approach will be coordinated with the participants of the Eco-Design TA.

WP0 Main Milestones planned for 2014:

- Rules of procedures for FRC-IADP management are settled and implemented
- Methodology defined for the extension of TE to mobility and productivity criteria
- Roadmap for Eco Design transversal activities settled

WP0 Main Deliverables planned for 2014:

- TE baselines and objectives for the Fast Rotorcraft demonstrations documented
- First selection of Eco-Design case studies issued.

WP0 Main Milestones planned for 2015:

- Dry run of augmented rotorcraft software platform (PHOENIX2)
- LCA methodology agreed with newly involved Core Partners and Partners

WP0 Main Deliverables planned for 2015:

- First TE assessment results for FRC
- First issue of bills of materials for fast rotorcraft configurations.

Year 2014

Overview

WP1 – NextGenCTR - Next Generation Civil Tiltrotor Demonstrator

During year 2014 the activities related to the following Work Packages will be launched.

WP1.0 – Management

This task is related to CS2 implementation, administration and management of technical activities and participation and preparation work to Clean Sky 2 committees.

WP1.1 / Task 1.1.1 – Concept & Integrated Systems Design

Task 1.1.1a (Aircraft Requirements Definition & General Architecture) will be performed in 2014 and 2015. This task can be split into different phases with due consideration of the CS2 objectives (i.e. CO2 and noise reduction) and technical engineering trade-off implications:

- First level aircraft sizing & preliminary design specification
Aircraft size, performance and general architecture definition.
- Aircraft systems trade studies
Detailed feasibility and trade studies on: proprotor, fuselage and wings, power plant, flight controls, hydraulics, fuel system, pressurization, avionics, EPGDS. The output will be the preliminary technical specifications for the individual systems.
- Aircraft systems design requirements & specifications
Definition of requirements for systems design, aerodynamic, aeroacoustic and flight mechanic modeling, analyses and simulations focused on the solutions selected during the previous step. The final step of Task1.1.1 is the definition of aircraft systems design requirements and specifications.

WP1.3 / Task 1.3.1 – Drive System Architecture Definition

A detailed feasibility study shall address drivetrain architectures, considering engine installation, integration of proprotor and proprotor actuator system, nacelle structure and aerodynamics, accessories location and sizing, weight, environmental impact and maintainability aspects.

The output will be the preliminary specification for the drivetrain system and related subsystems.

WP1.7 / T1.7.1 - Preliminary Activities Preparatory to Technology Evaluator Interface

In 2014 preliminary performance and mission analyses will be performed internally to establish and substantiate Key Performance Indicators and other suitable metrics to assess the progress towards the environmental objectives (i.e. CO2 and noise) within the NextGenCTR programme (T1.7.1.1) and feed into further assessments to be performed in the Clean Sky 2 TE Impact and Technology Evaluator.

The most suitable CTR baseline (T1.7.1.2) shall be defined; as such a reference is non-existent for tiltrotors.

A dedicated sub-task (T1.7.1.3) will perform a trade-off study to assess whether to adopt the tools already integrated in PHOENIX, or to develop and integrate civil tiltrotor (CTR) models based on different platforms (e.g. FlightLab).

In Task 1.7.1.4 and T1.7.1.5 non-environmental goals and related metrics and Key Performance Indicators will be defined to support assessments of transport productivity, time efficiency and ability to operate in confined spaces, as compared to conventional helicopters.

Major milestones planned for 2014:

- First Level Aircraft Sizing Complete - Internal report release
- Proprotor System Trade Studies Complete - Internal report release
- Fuselage and Wing Trade Studies Complete - Internal report release
- Airframe Systems Trade Studies Complete - Internal report release
- Drive Systems Trade Studies Complete - Internal report release
- First Iteration of Environmental Goals Metrics and KPIs Complete - Internal report release
- Civil Tilt Rotor Assessment Tools for CleanSky 2 objectives selected
- Non-Environmental Goals Defined – Internal report release
- System Requirement Review – Completed

Major deliverables planned for 2014:

- Preliminary Aircraft Design Specification – External report release
- Preliminary Engine Installation Specification – External report release
- Preliminary Drive System Specification – External report release

Year 2015

Overview

WP1.0 - Management

This task is a continuation of 2014 activities and remains related to CS2 implementation, administration and management of technical activities and participation and preparation work to Clean Sky 2 committees (i.e. Management Committee, Steering Committee).

WP1.1 / Task 1.1.1 – Concept & Integrated Systems Design

In 2015 the conceptual and preliminary design, analysis and studies still open will be completed, and the relevant deliverables will be issued.

A Preliminary Design Review (late-2015) to freeze the design and the general architecture will lead to Task 1.1.1b - Integrated System Design. In the meanwhile, the dedicated design of selected aircraft systems shall start.

WP1.2 / T1.2.1 – Proprotor design

Dedicated proprotor design will start beginning of 2015 and cover proprotor components (blades, hub, fixed/rotating controls, etc.) as well as proprotor assembly and installation, based on the preliminary design performed in WP1.1.

WP1.3 / T1.3.2 – Drive System detailed design

The preliminary design activity performed in T1.3.1 shall be completed by end of 2014 and feed T1.3.2, where further dedicated design of components will be performed.

WP1.4 / T1.4.1.1, 1.4.2.1, 1.4.3.1, 1.4.4.1 - Fuselage and Tilting Wing design

Dedicated modelling, analysis and design of all fuselage sections shall start beginning of 2015, in liaison with the outcomes of WP1.1 / T1.1.1a. Activities will be co-ordinated with respect to the Call for Core Partners in the Airframe ITD relevant to the 3 fuselage sections (T1.4.1, T1.4.2, T1.4.3) for integration of Core Partner activities as soon as possible in 2015.

T1.4.4 (wing dedicated design) will also start in 2015 and the launch of the Call for Core Partners planned in CPW2 in early 2015 for integration of Core Partner activities as soon as possible.

CPW2 – Core Partner Topic FRC-TR (WP1.4 / T1.4.4) – Design, manufacturing and testing of wing system components

WP1.5 / T1.5.1.1, 1.5.2.1, 1.5.3.1 – Nacelle, Fuel System and Engine Control System design

Dedicated design activity for the systems related to engine installation shall be launched in early 2015, including definition and design of engine installation, as well as of the engine control and fuel systems. The Core Partners for engine nacelle to be integrated into activities in 2015 whilst the fuel system partners possibly in 2016.

CPW2 – Core Partner Topic FRC-TR (WP1.5 / T1.5.1) – Design, manufacturing and testing of engine nacelle

PW2 – Partner Topic FRC-TR (WP1.5 / T1.5.2) – Design, manufacturing and testing of components of fuel system

WP1.6 / T1.6.1, 1.6.2, 1.6.3– Electric Power Generation and Distribution System (EPGDS), Flight control System (FCS) and Pressurization and Environmental Control System (ECS) design

These tasks will commence in beginning of 2015 and cover the design and development testing of Electrical power generation and distribution system (EPGDS), Flight control system (FCS) and Pressurization and environmental control system (ECS). Core Partners and Partners to be integrated as soon as possible in 2015.

CPW2 – Core Partner Topic FRC-TR (WP1.6 / T1.6.2) – Design, manufacturing and testing of components for flight control system

PW1 – Partner Topic FRC-TR (WP1.6 / T1.6.1) – Design, manufacturing and testing of components of EPGDS

PW2 – Partner Topic FRC-TR (WP1.6 / T1.6.3) – Design, manufacturing and testing of components of air management system

WP1.7 / T1.7.2 – Technology Evaluator Interface

The Work Package 1.7 – Technology Evaluator Interface shall complete the definition of metrics and Key Performance Parameters (KPP's) which will be used to assess the achievement of Clean Sky 2 environmental goals (i.e. CO₂ and noise emissions), and the selection of related tools and software. Furthermore, for the non-environmental goals outlined in Task 1.7.1.4 metrics and KPIs will be defined.

Task 1.7.2 shall start in 2015 with the following tasks:

- T1.7.2.1: definition of civil tiltrotor missions and operations;
- T1.7.2.2: synthesis of the civil tiltrotor baseline model;
- T1.7.2.3: synthesis of the Next Generation Civil TiltRotor model; this task will continue for the whole duration of *Clean Sky 2*

WP2 – LifeRCraft - Compound Rotorcraft Demonstrator

WP 2.0: Project Administration. Starting mid-2014, the LifeRCraft planning and reporting organization will be set up internally within the Leader's legal entities in line with the H2020 rules of participation and the operational procedures as agreed in WP0.1. Administrative activities will be implemented as soon as defined. In 2015, the Core Partners will implement a similar management organization in their own companies and start implementing it in coordination with the Leader.

WP 2.1: Project Management & Integration Activities. Starting mid-2014, the preliminary sizing and design of the demonstrator will be initiated by the LifeRCraft demo Leader. The relevant Clean Sky results e.g. rotor optimization techniques, airframe drag reduction solutions, advanced electrical systems projects, etc will feed this preliminary design. General aerodynamic and structural and mechanical studies will be engaged in support of the preliminary design process. The general specification of the demonstrator will be consolidated end of 2014. For the Technology Evaluator, a baseline for comparison will be established.

In 2015, the preliminary design will be completed with participation of the selected Core Partners and the PDR passed. Topic descriptions for CFP will be prepared and negotiation will be completed for contributions in the aerodynamic design including noise optimization studies (WP2.1.7) and vibration control (WP2.1.8). The development of compound rotorcraft conceptual model for TE will be initiated.

- W1 Partner Topic FRC2.1-1 - (WP2.1.7) Aerodynamic optimization for LifeRCraft
- W2 Partner Topic FRC2.1-2 - (WP2.1.8) Cabin active resonators for vibration control for LifeRCraft

WP2.2 through 2.12 – General description

In 2014, most of these WPs relevant to the components and subsystems will start mid-2014 at the same time and in coordination with the preliminary sizing and design of the complete demonstrator as conducted in WP2.1 in order to check the feasibility of each subsystem against its specific objectives and constraints. The candidate subsystem concepts will be compared, in support of that preliminary design process. Wherever necessary, topic descriptions will be prepared and issued for the first call for Core Partners aiming to involve strategic partners in the design and realization of the relevant components/subsystems. After selection of Core Partners by the JU, the LifeRCraft leader will enter into negotiation with the winning candidates in order to harmonize the work share until completion of the demonstration and conclude with them a Consortium Agreement. In the last quarter of 2014, some further topic descriptions will be prepared either for the 2nd Call for Core Partners or for the 1st Call for Partners, according to size and strategic character of the foreseen partnership. Participants to the WPs 2 to 12 will start contributing to the LifeRCraft preliminary design phase as they enter the Consortium end of 2014. The different work packages are assigned either to Core Partners or Partners mainly based only the estimated volume of activities and on the required level of system integration.

In 2015, all WP2 through 12 will be active and ramp-up substantially in order for the preliminary design studies of critical subsystems to be completed and the Preliminary Design Review to be passed end of 2015. Topic descriptions for the 2nd Call for Partners will be prepared either by the LifeRCraft leader or by the Core Partners in order to support further the design and realization process of other components and systems. Further topics will be prepared for WPs proposed in the 2nd Call for Partners planned to open mid-2015.

The paragraphs below only mention the distinctive activities of each WP, without repeating the generic aspects already explained above.

WP 2.2: Airframe Structure. Starting mid-2014, general structural concepts will be reviewed and assessed. Interfaces between major airframe sections will be established. In 2015, the construction technologies will be selected in liaison with Core Partners and the design and sizing process will be initiated with the support of stress analysis. WP2.2.5 (fuselage) to be proposed for a Core Partner in 2014. The WP2.2.6 (stress analysis, optimization) and 2.2.7 (fast prototyping) to be proposed for Partners in 2015. This WP will also coordinate activities performed in the Airframe ITD, WPs B1.1 and B4.1 in charge to design and deliver respectively the wing and tail section for the LifeRCraft demonstrator.

- CPW1 Strategic Topic FRC2.2-1 - (WP2.2.5) LifeRCraft airframe
The optimized main airframe supports the wing, the main gearboxes, and the engines. It includes the cabin, the cockpit and integrates the main system of the aircraft. The

activities cover the structural design according to Airbus Helicopters specification and architecture, the stress analysis, the manufacturing of the demonstrator airframe.

- W1 Partner Topic FRC2.2-2 - (WP2.2.6) Fuselage stress analysis and optimization
- W1 Partner Topic FRC2.2-3 - (WP2.2.7) Fuselage fast prototyping techniques

WP 2.3: Landing System. Starting fourth quarter of 2014, landing gear specifications to be defined and configuration to be selected in order to prepare the topic description for WP2.3.1 (design, manufacturing) to be proposed for the selection of a Partner. In 2015, the landing gear study will start with the selected Partner.

- W1 Partner Topic FRC2.3-1 - (WP2.3.6) Landing gear for LifeRCraft airframe

WP 2.4: Lifting Rotor. Starting mid-2014, requirements for rotor blades and hub will be specified. Different options for either reusing some existing helicopter design or defining new/modified design will be assessed in order to found the best trade-off between performance, loads and noise. In 2015, the design option(s) will be selected at the PDR based on further studies.

WP 2.5: Propellers. Starting mid-2014, descriptions of WPs 2.5.8 (aeroacoustic design & tailoring) and 2.5.9 (mechanical design, realization) will be prepared to be proposed for Partners in 2015. In 2015, the propeller design process will start with the Partners.

- W1 Partner Topic FRC2.5-1 - (WP2.5.8) Propeller aero-acoustic optimization (noise, performance)
- W1 Partner Topic FRC2.5-2 - (WP2.5.9) Propeller mechanical design and manufacturing

WP 2.6: Mechanical Drive System. Starting mid-2014, the general architecture for power transmission from engines to rotor and props will be reviewed and assessed in coordination with the general demonstrator architecture studies. Specifications for gearboxes and shafts will be established. Topic descriptions will be derived for: WP2.6.9 (Main Gear Box modules, Propeller Gear Boxes) proposed for a Core Partner in 2014; WP2.6.10 (Propeller coupling shafts) for a Partner in 2015. In 2015, the LifeRCraft leader will proceed with design studies for the Main Gear Box.

- CPW1 Strategic Topic FRC2.6-1 - (WP2.6.9) - LifeRCraft drive system - Two propeller gearboxes (LH & RH) and specific MGB modules have to be developed for the compound MGB (MGB derived from an existing MGB). The activities cover the design according to Airbus Helicopters specification and architecture, the stress analysis, the manufacturing of the gearboxes for ground tests and flight tests, and the analysis of the tests results.
- W2 Partner Topic FRC2.6-2 - (WP2.6.10) Propeller coupling shafts

WP 2.7: Power Plant. Starting fourth quarter of 2014, the engine specifications and installation requirements will be established based on the preliminary estimation of LifeRCraft performance (altitude envelope, power rating, fuel consumption, power turbine speed range). As these specifications will evolve with the refinement of preliminary design, the description of WPs 2.7.2.2 (turboshaft engine) is expected to be settled only by mid-2015 and proposed in the 2nd Call for Partners.

- W2 Partner Topic FRC2.7-1 - (WP2.7.2.2) Turboshaft engine adaptation and installation

WP 2.8: Electrical System. Starting mid- 2014, the electrical system study will start and based on technologies selected in the GRC ITD, it will allow proposing an electrical architecture consistent with the LifeRCraft specific configuration and producing several topic descriptions corresponding to WP2.8.7 (generation, storage, conversion), intended to engage Partners after selection in the 1st or 2nd Call for Partners.

- W1 Partner Topic FRC2.8-1 - (WP2.8.7) Electrical generation
- W1 Partner Topic FRC2.8-2 - (WP2.8.8) Electrical storage
- W1 Partner Topic FRC2.8-3 - (WP2.8.6) Electrical converters

WP 2.9: Actuators. The activity will start only in 2015, after sufficient progress in the design of the flight control system. Several topics corresponding to specific actuator requirements (e.g. WP 2.9.4.2, 2.9.5.2) are expected to be ready for the 2nd Call for Partners due to open mid-2015.

- W2 Partner Topic FRC2.9-1 - ((WP2.9.8) Flight control actuators

WP 2.10: Avionics & Sensors. The activity will start in the fourth quarter of 2014 aiming at pre-selecting the avionic suite and equipment from existing hardware as best suited for the LifeRCraft demonstration. The selection may subsequently evolve as desired functionalities or performance could change according to the progress in WP2.12. No call topics expected to be launched in 2014-2015.

WP 2.11: Cabin & Mission Equipment. The activity will start only in 2015, after sufficient progress in the design of airframe and cabin. Several topics corresponding to specific cabin/mission systems (e.g. WP 2.11.2.2 for noise control; or 2.11.4.2 for cabin access) are expected to be ready for the 2nd Call for Partners.

- W2 Partner Topic FRC2.11-1 - (WP2.11.2.2) Interior noise control
- W2 Partner Topic FRC2.11-2 - (WP2.11.4.2) Equipment for cabin access

WP 2.12: Flight Control, Guidance, Navigation. In 2014, the different Flight Control System options will be compared, in terms of work load reduction, safety, complexity and cost. In parallel, studies for compound rotorcraft specific flight operations for environmental protection will start based on results obtained in CS-GRC5 for conventional helicopters. Two

topic descriptions (WP2.12.2.2 – flight profiles for fuel savings, and 2.12.3.2 – design of terminal procedures for low noise) are expected to be ready for the 1st Call for Partners.

- W1 Partner Topic FRC2.12-1 - (WP2.12.2.2) Flight profile for fuel saving
- W1 Partner Topic FRC2.12-2 - (WP2.12.3.2) Noise abatement flight procedures

Major milestones planned for 2014:

- LifeRCraft general requirement specs and preliminary component interfaces defined

Major deliverables planned for 2014:

- Strategic Topics defined for the first 2 Calls for Core Partners
- Topics defined for the first Call for Partners

Major milestones planned for 2015:

- LifeRCraft Preliminary Design Review passed

Major deliverables planned for 2015:

- Topics defined for the first Call for Partners
- LifeRCraft wind tunnel model (WP2.1.4)

Implementation

The activities in the Fast Rotorcraft IADP will be performed following the general principles of the Clean Sky 2 membership and participation.

Airbus Helicopters and Augusta Westland, as the IADP Leaders, will perform the main activities related to the technology development and demonstration in the IADP. Significant part of the work will be performed by Core Partners, supporting the IADP leader in its activities. Finally, another part of the activities will be performed by Partners through Calls for Proposals for dedicated tasks.

Airbus Helicopters and Augusta Westland, as the IADP Leaders, will sign the one Grant Agreement for Members (GAM) in order to perform the work. This GAM will cover all the work of the Members in this IADP. The Core Partners are selected through open Calls for Core Partners and the retained applicants will accede to the existing Grant Agreement for Members. Partners will be selected at a later stage through Calls for Proposals and will be signing the Grant Agreement for Partners. They will be linked to the IADP activities through the Coordination Agreement.

The following topics are opened for the first call for Core Partners:

JTI-CS2-CPW01-FRC	
JTI-CS2-2014-CPW01-FRC-02-01	LifeRCraft airframe - Central and front fuselage sections - Design, Optimization, Manufacturing, V&V including airworthiness substantiation
JTI-CS2-2014-CPW01-FRC-02-02	LifeRCraft drive system - Main Gear Box input modules and equipped Propeller Gear Boxes - Design, Optimization, Manufacturing, V&V including airworthiness substantiation

Detailed description of the topics is provided in ***Annex I - 1st Call for Core-Partners: List and Full Description of Strategic Topics.***

Type of action: *[Innovation action, funding rate 70%⁹]*

⁹ Research organisations may apply for the 100% funding rate in accordance with H2020 rules

9.4. ITD AIRFRAME

In the Smart Fixed Wing project in *Clean Sky*, a more efficient wing with natural laminar flow, optimised control surfaces and control systems will be demonstrated. Also, novel engine integration strategies will have been derived and tested, and innovative fuselage structures investigated. Progress towards the 2020 targets will be significant, but efforts remain necessary - in particular for the most complex and challenging requirement on new vehicle integration – to reach these objectives and start towards the 2050 SRIA goals. The Airframe ITD will target significant gains in the following areas:

- Introducing innovative/disruptive configurations enabling a step-change in terms of efficiency
- Developing more efficient wings: Further important gains can be obtained combining:
 - Weight-optimized use of composites on very high aspect ratio wings,
 - Cost effective production of laminar wings and use of hybrid laminar flow technology,
 - Full scale demonstration of the aero efficiency of low cost wings and of high-lift wing concepts
- Developing fuselages with optimized usage of volume and minimized weight, cost and environmental impact. Step changes in efficiency and environmental impact are expected from:
 - Optimized shapes of fuselage and cockpit,
 - Optimized use of metallic and composite materials,
 - New integration of components and systems, as well as advanced integrated structures
- Developing an enhanced technology base in a transverse approach towards airframe efficiency to feed the demonstrators on synergetic domains such as:
 - Efficient wing technologies,
 - Hybrid laminar flow technologies,
 - New production and recycling techniques,
 - Progress on certification processes and associated modelling capacities which will be key to facilitate the market access of future step changes.

All those streams have shown feasibility to be developed into a more complex and demanded structural components to be used into Clean Sky 2 platforms.

Description of activities 2014-2015

The activities in 2014 will mainly consist in initiating the definition works of the first set of AIRFRAME's technology developments and demonstrators, leading to the high level description of objectives and requirements for those demonstrators. In addition, a refinement and detailing of the overall technical definition of the Clean Sky 2 programme will be carried out, enabling the sublevel definition of the WBS, as required from the expert panel's review of 2013. The refinement will be supported via design studies and manufacturing trials of wingbox structures benefitting from experience gained in Clean Sky, and here further

matured and enhanced. Planning of technical activities covering the complete Clean Sky 2 programme and the associated schedule definition will be matured and developed. The proper interfacing between the AIRFRAME ITD and the IADPS and other ITD will be set up.

On 2014 and till mid 2015, Technical requirements for key contributions from Core Partners will be scoped and described, then discussed with the selected core partners in order to infer the technical description of planned developments from Core Partners.

Based on a successful selection of the first batch of core partners, those activities will be continued in 2015 with inserting analysis from engaged Core Partners, with the target to achieve the preliminary definition of first scheduled demonstrators. Trade-offs analysis will consolidate the definition of selected concepts, behavior analysis will support the study of advanced integration of system in structure and MDO approach will support the demonstration specification phase to be initiated in 2015.

Due to the large scope of technologies undertaken by the Airframe ITD, addressing the full range of aeronautical portfolio (Large passenger Aircraft, Regional Aircraft, Rotorcraft, Business Jet and Small transport Aircraft) and the diversity of technology paths and application objectives, the technological developments and demonstrations are structured around 2 major Activity Lines, allowing to better focus the integrated demonstrations on a consistent core set of user requirements, and, when appropriate, better serve the respective IADPs:

- Activity Line 1: Demonstration of airframe technologies focused toward High Performance & Energy Efficiency; Related Technology Streams are noted “A” hereafter.
- Activity Line 2: Demonstration of airframe technologies focused toward High Versatility and Cost Efficiency. Related Technology Streams are noted “B” hereafter.

Technology Stream A-1: Innovative Aircraft Architecture

The activities will first focus on the selection of routes for the advanced optimization of engine integration on rear fuselage and on advanced power-plant solutions (UHBR and CROR) to achieve a significant gain in aircraft performance (aerodynamics, acoustics, weight). All enabling simulation and testing technologies to achieve this goal will be developed or if already existing adopted to the given needs. From pure technology perspective all necessary investigations will be performed which support a complete characterization of the advanced power-plant solutions, such as wind tunnel tests, acoustic test or dedicated component tests. Preliminary definition of requirements for advanced efficient certification process will be elaborated.

Technology Stream A-2: Advanced Laminarity

The activities will first focus on the selection of a representative configuration for demonstration of laminar nacelle and initial investigation of manufacturing technologies / potential partners in order to identify the most suitable for reliable production of high quality/low tolerance external surface. Initial specification of a representative demonstration

will be developed in 2015, in parallel to the investigation on operational aspects (e.g. ventilation and accessibility) linked to repositioning of operational hatches in the non-laminar zone. For the Natural Laminar Flow (NLF) smart integrated wing, definition and preparation of work for ground tests with respect to structure and systems verification and validation will be performed. Based on a preparation phase in 2014 performed in German funding project scheme, the plan is to perform in this work package in 2015 a flight test with a NLF Horizontal Tail Plan mounted on A320 to validate the chosen structural concept.

Preparation works will also already during 2014 consist of wing box design studies, benefitting from the highly integrated wing box upper cover design initiated in Clean Sky SFWA. The concept will be further developed and matured, focusing on specific topics identified as critical for achieving a more complete NLF concept in the long term perspective and as such enable reaching higher TRL levels in Clean Sky 2. Development trials will be conducted in 2014 potentially supported by additional trials in 2015, required to conduct proper assessment of strength capability and manufacturability.

Technology Stream A-3: High Speed Aircraft

The initiation works will first focus on fuselage structures with new materials. First material characterization and analysis on structure's design will start in 2015. Initial work on new concepts for Design for Manufacturing will be started focusing on door structures and integration. Preliminary concepts of optimization of complex shape structure of rear fuselage will be identified in 2015. With respect to wing, initial investigation will address high aspect ratio wing for large civil aircraft with structure efficient, stringer dominated design. Innovative architectures for tail plane stabilizers and ailerons for large passenger aircrafts will also start to be assessed. In 2015, wing planform, structure concepts and system/moveable integration for a high aspect ratio wing will be matured. Based on the most promising tails architectures elaborated in 2014 the initial shape design will take in place in 2015. In terms of ECO Design two main activities will be carried out:

- Elaboration of a list of new technologies not considered on Clean Sky / Eco-Design ITD and promising in terms of environmental benefits. Selection of the most promising for a development after 2015.
- Studies on the viability of re-using recycled Carbon Fibres in aeronautical or aerospace products will be started.

Technology Stream A-4: Novel Control

The activities will first focus on strategies selection for load alleviation and concept identification for integrated movable surfaces. Analysis of control techniques and system architecture for load alleviation will start in 2015. Initial design work of an integrated slat will start in 2015. In 2014 activities will concentrate on the definition of wing concepts featuring an active winglet for load and span control. Based on this preliminary concept phase, the work in 2015 will focus on initial wing/winglet aero shape design and the definition of folding kinematics and movables concepts.

Technology Stream A-5: Novel Travel Experience

The activities will first focus on the identification of the key enablers and technology drivers that will support the flexible, ergonomic and attractive cabin. Passenger behavioral analysis and specification of innovative equipment will start in 2015. Human factors related with cabin, systems and structure integration will be studied.

Technology Stream B-1: Next generation optimized wing

The activities will first focus on the consolidation of the activity plan and the integrated approach with the R-IADP for the new outer wing concept including wing, winglet, aileron and spoiler. In addition, the capabilities required for a call for core partners to support Out of Autoclave (OoA) composite manufacturing and multifunctional design applicable to the mentioned components will be described (based on previous experience in CS and national projects), in conjunction with the starting of the OoA SAT activities as describe in the SAT dedicated chapter of the present Work Plan. These activities will concurrently address the integrated approach with the FRC-IADP for the specific concept of a wing providing additional lift as suited for the compound rotorcraft demonstrator. A Core Partner able to design and manufacture and deliver this full scale flightworthy wing for the compound rotorcraft will be called and engaged in 2014.

Based on the state-of-the-art of applied flow control technologies, developed so far in European and National research projects, the activities in 2014/2015 will concentrate clearly on the robust design of the most promising flow control technologies, capable of being integrated and tailored to the objectives set in the IADP-LPA, Platform 1.

Technology Stream B-2: Optimized high lift configurations

The activities will first focus on the consolidation of the activity plan and the integrated approach with the R-IADP for a new morphing flap and multifunctional nacelle cowlings. SAT High Lift Wing activities will start (refer to the SAT dedicated chapter of the present Work Plan). In addition, the capabilities required for a core partners to support the definition and manufacturing of this flap will be described. One call for core partner will be launched covering the needs of B-1 and B-2.

In 2015, for B-1 and B-2, the structural preliminary design of the mentioned components will be launched, in parallel with the work at the RA IADP, that will perform the necessary trade-offs to define flap/winglet/etc, concepts. Based on MDO approach, the wing/ flap structural preliminary design will start during 2015.

Technology Stream B-3: Advanced integrated structures

The activities will first focus on the technical description of activities as well as capabilities required for Core partners in more electrical wing. Secondly, they will cover in wing system installation, electrical distribution, actuation systems, structure embedded SATCOM, and anti-ice systems.

Capitalizing on the CS activities in the cockpit, in 2015 will be performed the analysis of the electrical behavior of the composite cockpit and development of the electrical structural network and the definition of the detailed technical specifications for the systems included in the cockpit as well as the more electrical wing (actuation, morphing devices, electrical distribution, cockpit system installation and SHM) and nacelles. Cockpit noise attenuation means will be investigated.

SAT activities related to advanced integration of System and affordable manufacturing will start (refer to the SAT dedicated chapter of the present Work Plan).

Activities concerning the Integration of Systems in Nacelle (WP B-3.3), in 2015 will consist of the technical specifications for the systems (e.g. Anti-Ice, Acoustic liner) to be included in the Nacelle together with the definition (preliminary) of the testing campaigns (Full Scale Demonstrators) and Test Plans.

Technology Stream B-4: Advanced fuselage

B-4.1. In 2014, the general specification of the rotor-less tail for the compound rotorcraft demonstrator will be derived as part of the coordinated activity with the FRC-IADP. The Core Partner joining the Consortium to support OoA composite manufacturing and multifunctional design (see WP B1.1) will also be engaged for and tasked with the design and manufacturing of this flightworthy tail unit.

In 2015, the preliminary design and optimization studies of the tail unit structure will be completed. The PDR to be passed at the end of the year will validate the selected structural architecture and design. Two CFP Topics may be opened in 2015 in order for expert labs to further support the detailed design and optimization process and manufacturing activities in the subsequent steps of this WP.

B-4.2. Along with the activities associated to the definition of NextGenCTR's general architecture and technical requirements at major system level in Fast Rotorcraft IADP, trade-off studies and elaboration of configuration and requirements for pressurized fuselage will be done at a first stage (2014). This work will be used to develop and issue technical specification to provide clear requirements to start design activities in the following period (2015). Down selection of key technologies will be part of this activity, together with the definition of major testing and validation activities planned for the following years. It is expected that one Call for Core Partners for the development of a large structural elements will be issued in 2015, complemented by CfP to address specific needs on design activities.

B-4.3. In 2014, the technical description of overall activities as well as capabilities required for Core partners to be firstly involved within the More Affordable composite fuselage will be provided. The following activities will be performed: i) architectural trade-offs for fuselage preliminary definition considering the relevant technologies; ii) preliminary requirements for manufacturing tools in order to develop and set up the processes to be used for fuselage components; iii) preliminary requirements specification of methodologies for design, manufacturing, assembling, maintenance, repair for SHM technologies integration.

In 2015, the activities will focus on: i) fuselage conceptual design; ii) preliminary requirements for pilot fabrication facilities; iii) identification of methodologies for design, manufacturing, assembling, maintenance, repair of SHM integrated technologies on fuselage barrel.

B-4.4. The activities will first focus in 2014 on the identification of the comfort key factors and technology drivers that will support in 2015 the innovative and integrated design approach for Multidisciplinary human centred Cabin as well as the Core Partners capabilities to be firstly involved.

Major milestones planned for 2014:

- Refined description of the AIRFRAME technical objectives
- Contribution to the definition of strategic topics descriptions for Core Partners Selection and support to the selection process of the first batch of Core Partners
- AIRFRAME Annual Review

Major Deliverables planned for 2014:

- Contribution to the strategic topic descriptions for the first wave of Core Partners. Foreseen topics are listed on table at end of this AIRFRAME section
- High-level description of objectives and requirements of initial demonstrators
- Preliminary requirements for more affordable manufacturing, assembly, processes & tools for both metallic and composite structures
- Preliminary requirements of quality manufacturing for laminar surface
- Preliminary design concepts for laminar surfaces, and assessment of results from initial development trials for evaluation of strength capability and manufacturability.

Major milestones planned for 2015:

- Engagement of Core Partners
- Start of first demonstrator concept design (wing concept, laminar nacelle concept, NFL smart integrated wing & HTP, aileron concept, design for manufacturing concept, complex rear fuselage structure, high aspect ratio flexible wing, integrated system concept, integrated nacelle, composite fuselage concept, human centered cabin concepts) on the basis of Clean Sky OAD results
- Start of technology developments for airframe, components, composite structures and automated assembling in line with the SAT RA and Rotorcraft focused demonstration roadmap
- Initialization of technology developments
- AIRFRAME Annual Review
- Completion of preliminary design phase for structural components of the compound rotorcraft demonstrator, in coordination with the FRC-IADP

Major Deliverables planned for 2015:

- Requirement specifications for Core Partner technical activities for the anticipated call batches in 2014/2015. Foreseen topics are listed on table at end of this AIRFRAME section
- Concept guidelines for each of initial demonstrators
- High level description of initial technology developments
- Initial manufacturing requirements for key pilot items for more affordable composite fuselage
- Technical specifications for the systems to be included in the integrated Nacelle and definition (preliminary) of the testing campaigns (Full Scale Demonstrators) and Test Plans
- Topic descriptions for CFP n°1 and 2
- Manufacturability analysis and trials of highly integrated structural concepts for control surfaces tail plane stabilizers and wingbox upper covers, (based on the previous technology development performed in national research projects)
- Preliminary paper analysis of the effects of a highly integrated cabin on flight operators, passengers and users.
- Technical description and specification of pressurized fuselage for fast rotorcraft demonstrator
- Eco-Design: list of technologies/process selected for development after 2015

Implementation

The activities in the Airframe ITD will be performed following the general principles of the Clean Sky 2 membership and participation.

Dassault Aviation, EADS-CASA and Saab, as the ITD Leaders, will perform the main activities related to the technology development and demonstration in the ITD. Significant part of the work will be performed by Core Partners, supporting the ITD leader in its activities. Finally, another part of the activities will be performed by Partners through Calls for Proposals for dedicated tasks.

Dassault Aviation, EADS-CASA and Saab, as the ITD Leaders, will sign the one Grant Agreement for Members (GAM) in order to perform the work. This GAM will cover all the work of the Members in this ITD. The Core Partners are selected through open Calls for Core Partners and the retained applicants will accede to the existing Grant Agreement for Members. Partners will be selected at a later stage through Calls for Proposals and will be signing the Grant Agreement for Partners. They will be linked to the ITD activities through the Coordination Agreement.

The following topics are opened for the first call for Core Partners:

JTI-CS2-2014-CPW01-AIR	
JTI-CS2-2014-CPW01-AIR-01-01	New Innovative Aircraft Configurations and Related Issues
JTI-CS2-2014-CPW01-AIR-01-02	e-WIPS integration on novel control surface
JTI-CS2-2014-CPW01-AIR-02-01	New wing and aircraft systems design and integration for Turboprop regional aircraft
JTI-CS2-2014-CPW01-AIR-02-02	Wing and Tail Unit Components Multifunctional Design and Manufacturing (including Out of Autoclave composite)
JTI-CS2-2014-CPW01-AIR-02-03	Advanced technologies for more affordable composite fuselage
JTI-CS2-2014-CPW01-AIR-02-04	Design and manufacturing of an advanced wing structure for rotorcraft additional lift

Detailed description of the topics is provided in ***Annex I - 1st Call for Core-Partners: List and Full Description of Strategic Topics.***

Type of action: [Innovation action, funding rate 70%¹⁰]

¹⁰ Research organisations may apply for the 100% funding rate in accordance with H2020 rules

9.5. ITD ENGINES

As defined in Clean Sky, the objective of the Sustainable and Green Engines (SAGE) is to build and test five engine ground demonstrators covering all the civil market. The goals aim at validating to TRL 6 a 15% reduction in CO₂ compared to 2000 baseline, a 60% reduction in NO_x and a 6dB noise reduction. This is roughly 75% of the ACARE objectives. Whereas some activities were delayed for the Open Rotor programme for example, the bulk of SAGE objectives remain on track.

Clean Sky 2 will build on the success of SAGE to validate more radical engine architectures to a position where their market acceptability is not determined by technology readiness. The platforms or demonstrators of these engines architectures can be summarized as below:

- Open Rotor Flight Test, 2014-2021: a second version of a Geared Open Rotor demonstrator carrying on *Clean Sky* SAGE 2 achievements and aimed at validating TRL 6;
- Ultra High Propulsive Efficiency (UHPE) demonstrator addressing Short / Medium Range aircraft market, 2014-2021: design, development and ground test of a propulsion system demonstrator to validate the low pressure modules and nacelle technology bricks;
- Business aviation / short-range regional Turboprop Demonstrator, 2014-2019: design, development and ground testing of a new turboprop engine demonstrator in the 1800-2000 shaft horse power class;
- Advanced Geared Engine Configuration, 2015-2020: design, development and ground testing of a new demonstrator to validate key enablers to reduce CO₂ emissions and noise as well as engine mass;
- Very High Bypass Ratio (VHBR) Middle of Market Turbofan technology, 2014-2018: development and demonstration of technologies in each area to deliver validated powerplant systems matured for implementation in full engine systems;
- VHBR Large Turbofan demonstrator, 2014-2019: design, development, ground and flight test of an engine to demonstrate key technologies at a scale suitable for large engines;
- The Small Aero-Engine Demonstration projects related to Small air Transport (SAT) will focus on small fixed-wing aircraft in the general aviation domain and their power-plant solutions, spanning from piston/diesel engines to small turboprop engines.

Description of activities 2014-2015

Work Package 1 – Open Rotor flight Test (Snecma)

During the second half of 2014 and 2015 only WP 1.1 (Propulsion System Integration), WP 1.2 (Modules Adaptation or Modifications) and WP 1.3 (Systems and Controls Development) will be active.

The analysis of gap between Ground Test Demonstrator (GTD) status and Flight Test Demonstrator (FTD) specifications will be performed, including control system requirements (control laws, engine and fire protections, etc). After airworthiness analysis and taking into account previous studies, it will be decided what non flight-able parts from SAGE 2 GTD propeller module will have to be re-designed. It is foreseen some nacelle components will be new or adapted to the FTD (air intake, gas generator dressing, engine mounts...) as well as some systems components (accessories gearbox, starter, oil modules...). The Preliminary Design Phase for the modified modules, including the impact on overall engine behaviour (integration, installation...) will start mid-2015 and will be completed in 1st quarter of 2017.

Work Package 2 – Ultra High Propulsive Efficiency (UHPE) Demonstrator for Short / Medium Range aircraft (Snecma)

The activity will start in the 4th quarter of 2014 in WP 2.1 (WP 2.1: Candidate, Concept, Demo Architecture, and Demo Integration). Several ultra-high bypass ratio (UHBR) turbofans architectures for high propulsive efficiency concepts (engine + nacelle + systems) will be drafted and their overall interest evaluated using preliminary studies tools (specific fuel consumption, noise emissions, drag and weight).

In 2015 a preferred candidate to power the Short / Medium Range aeronautic transport will be selected to give rise to the choice of the UHBR demonstrator concept/architecture in 2016. The selection process will include the check of sufficient technology readiness level to allow ground test at the scheduled date in Clean Sky 2 and then to enter in service within 2025-2030.

Work Package 3 – Business Aviation / Short Range Regional TP Demonstrator (Turbomeca)

WP03 is split into 6 subprojects: Integration of the propulsion system, Core engine adaptation for turboprop usage, Gear box module, Propeller, Air intake & Nacelle, Innovative accessories and equipments.

2014 activities will focus on the high level specifications of the Integrated Power Plant System with the support of an airframer and the preparation of the calls for the Core Partners.

2015 will be dedicated to the preliminary design of the whole Integrated Power Plant System (IPPS). At the end of 2015, the architecture of the IPPS will have been selected and the specifications of each subsystem will be available. Management activities will consist in

participating to Steering Committees, interfacing with the IADP (Rotorcraft, RA) and SAT. The first Calls for Proposals will be issued.

Work Package 4 – Adv. Geared Engine Configuration (HPC-LPT) (MTU)

Key objectives of the activities in 2014 and 2015 are the definition and preparation of the entire programme. Up to mid of 2014 conceptual design studies for Engine Demo and Rigs will be performed to define basic configurations for the demonstrator vehicles. These studies will include all modules outlined in the joint technical proposal. As a result preliminary requirement documents will be established. It will be ensured that the validation requirements for the defined technologies can be met in order to finally achieve TRL6. The preliminary concept definitions will also be used to specify the contribution of core partners and partners.

In the 4th quarter of 2014 and enforced in 2015 a first identification and selection of the technology streams will be carried out to ensure that the selected technologies will be available at the necessary TRL level for incorporation in the demonstrator vehicles. Starting in 2015 the engineering team will be ramped up.

The conceptual design studies will be continued for Engine Demo and Rigs under the assumptions of the preselected technologies. Main focus are on the materials and manufacturing technologies and further design features as the main contributors to meet the overall Clean Sky 2 objectives and achievements. A concept review will be performed end of 2015.

Further activities will be launched to support the core partner selection process in the first 2 waves as well as the first call of call for proposals

Work Package 5 – VHBR – Middle of Market Technology (Rolls-Royce)

Throughout the course of the programme, work package 5 will demonstrate a range of underlying technologies necessary for very high bypass ratio (VHBR) engines in all markets, although focusing on Middle of Market short range aircraft. A series of design studies and rig tests will deliver TRL4-5 for each technology in 2018, feeding full system demonstration in other programmes.

Having already established a strong technical management organisation, the ramp-up of engineering resource and work will be significant and is reflected in the budget planned for the period. 2014 will see the immediate launch of this work package, initiating studies and conceptual design of low speed fan/pressure systems, low pressure turbines optimized to high speed operation, the system integration of power gear systems, optimized power plant and nacelle technology, and compressor systems. The requirements and verification strategies for the technologies will be authored, and detailed design will follow. Early 2014 Core partner engagement is essential – for VHBR engine LP turbine and Structural technology.

The programme will continue to accelerate through 2015, where all required technologies will achieve Concept design review, bench and rig verification will start, and preparations begin for the manufacture of long lead-time hardware to support delivery to WP6 in 2018.

Work Package 6 – VHBR – Large Turbofan Demonstrator (Rolls-Royce)

Work package 6 targets the extension of Very High Bypass Ratio technologies to large engines for the long range airliner market. Building on the technology validation delivered by WP5, the project will develop these for higher power engines and ultimately demonstrate the technology at full system level in ground and flight test in order to achieve TRL 6 in 2019 in preparation for the next generation of wide body airliners.

Throughout 2014, conceptual engine studies will be completed, trade studies undertaken, and whole-engine architectural options down-selected (in conjunction with the LPA IADP) to define the demonstrator. The whole engine requirements and validation strategy will be authored, culminating in completion of the concept review in 2015. Additionally, an initial study into modifications required to test facilities and flight test aircraft to support the demonstrator will be undertaken.

Progress will accelerate significantly through 2015, when the preliminary design will continue, and provisions are made to begin manufacture and procurement of long-lead time items which will be required to be delivered to stores for engine test in 2018. Tools, instrumentation, and methods to support the verification programme will be reviewed alongside functional modelling of the engine to support the technical evaluation program.

Work Package 7 – Small Aircraft Engine Demonstrator

Work Package 7 relates to Small Air Transport (SAT) and will focus on small fixed-wing aircraft in the general aviation domain, and their power-plant solutions spanning from piston/diesel engines to small turboprop engines. This area in the Engines ITD will focus on light weight and fuel efficient diesel engines and on turbine activities with power range suitable for general aviation.

Please refer to SAT chapter for more details.

Key Engine ITD Deliverables

WP1 – Open Rotor Flight Test

- Gaps between GTD status and FTD specifications
- List of SAGE 2 GTD parts to re-designed / adapted incl. objectives

WP2 – Ultra High Propulsive Efficiency (UHPE) Demonstrator for Short / Medium Range Aircraft (Snecma)

- Report on UHPE concept studies to feed ground test demo concept study in 2016

WP3 – Business aviation / short range Regional TP Demonstrator

- Call for Core Partners available: PGB/AGB,
- Call for Core Partners available: Propeller and pitch control system
- IPPS Architecture & Specification
- Minutes of Design Review

WP4 – Adv. Geared Engine Configuration (HPC-LPT)

- Minutes of Interims Concept Review
- Preliminary Module Descriptions
- Minutes of Concept Review

WP5 – VHBR – Middle of Market Technology

- Technical requirements documentation for VHBR technologies issued
- Scope of work defined: Low speed fan system & Structural Technology
- Scope of work defined: High speed LP Turbine

WP6 – VHBR – Large Turbofan Demonstrator

- Technical requirements documentation for VHBR demonstrator issued

WP7 – Small Aircraft Engine Demonstrator

- Turbine engine – content to be defined following CP selection
- Engine architectures Analysis
- Engine Final design
- Endurances analysis

Key Engine ITD Milestones

WP1 – Open Rotor Flight Test

- First conclusion of airworthiness and FTD specifications studies

WP2 – Ultra High Propulsive Efficiency (UHPE) Demonstrator for Short / Medium Range Aircraft

- UHPE concept selection to give rise to UHBR ground demo

WP3 – Business aviation / short range Regional TP Demonstrator

- PDR

WP4 – Adv. Geared Engine Configuration (HPC-LPT)

- Interims Conceptual Design Review
- Conceptual Design Review

WP5 – VHBR – Middle of Market Technology

- Concept Reviews for VHBR technologies complete

WP6 – VHBR – Large Turbofan Demonstrator

- Concept Reviews for VHBR technologies complete

WP7 – Small Aircraft Engine Demonstrator

- Diesel Engine road map with partners
- Prototype Test Cell First Run
- Engine Installed First Run (Ground)
- First Flight

Implementation

The activities in the Engines ITD will be performed following the general principles of the Clean Sky 2 membership and participation.

Safran, Rolls-Royce and MTU, as the ITD Leaders, will perform the main activities related to the technology development and demonstration in the ITD. Significant part of the work will be performed by Core Partners, supporting the ITD leader in its activities. Finally, another part of the activities will be performed by Partners through Calls for Proposals for dedicated tasks.

Safran, Rolls-Royce and MTU, as the ITD Leaders, will sign the one Grant Agreement for Members (GAM) in order to perform the work. This GAM will cover all the work of the Members in this ITD. The Core Partners are selected through open Calls for Core Partners and the retained applicants will accede to the existing Grant Agreement for Members.

Partners will be selected at a later stage through Calls for Proposals and will be signing the Grant Agreement for Partners. They will be linked to the ITD activities through the Coordination Agreement.

The following topics are opened for the first call for Core Partners:

JTI-CS2-2014-CPW01-ENG	
JTI-CS2-2014-CPW01-ENG-01-01	Low Pressure Turbine Rear Frame (LP TRF) and Low Pressure Spool Shaft (LPS) for Ultra High Propulsive Efficiency (UHPE) Demonstrator for short / Medium Range Aircraft (WP2)
JTI-CS2-2014-CPW01-ENG-01-02	Power GearBox (PGB) for Ultra High Propulsive Efficiency (UHPE) Demonstrator for Short/Medium Range Aircraft
JTI-CS2-2014-CPW01-ENG-01-03	Business Aviation / Short Regional TP demonstrator Front Power Plant Module
JTI-CS2-2014-CPW01-ENG-02-01	Aerodynamic Design and Testing of advanced Geared Fan Engine Modules
JTI-CS2-2014-CPW01-ENG-02-02	LPC, ICD and TEC development for next generation geared fan engines
JTI-CS2-2014-CPW01-ENG-03-01	VHBR Engine - IP Turbine Technology
JTI-CS2-2014-CPW01-ENG-03-02	VHBR Engine Structural Technology
JTI-CS2-2014-CPW01-ENG-04-01	More advanced and efficient small turbine engines for SAT market

Detailed description of the topics is provided in ***Annex I - 1st Call for Core-Partners: List and Full Description of Strategic Topics.***

Type of action: *[Innovation action, funding rate 70%¹¹]*

¹¹ Research organisations may apply for the 100% funding rate in accordance with H2020 rules

9.6. ITD SYSTEMS

Systems and equipment play a central role in aircraft operation, flight optimisation and air transport safety:

- Direct contributions to environmental objectives: for example optimized green trajectories or electrical taxiing have a direct impact on CO₂ emissions, fuel consumption, etc.
- Enablers for other innovations: in particular for innovative engines or new aircraft configurations;
- Enablers for air transport system optimization: improving greening aviation, mobility or ATS efficiency can only be reached through the development and the integration of on-board systems;
- Smart answers to market demands: systems and equipment have to increase their intrinsic performance to meet new aircraft needs without a corresponding increase in weight and volume.

Starting from the *Clean Sky* developments through Systems for Green Operations (SGO), further maturation, demonstration and new developments are needed to accommodate the needs of the next generation aircraft. Clean Sky work on green trajectories has shown that significant improvements are possible to reduce CO₂ emission, fuel consumption, and perceived noise in specific flight phases. The next step, to be developed in Clean Sky 2, is to integrate these results in a multi-criteria optimisation process of the whole flight plan, to allow for:

- Global optimisation taking into account the whole flight and ATS constraints.
- Possibility to introduce new criteria depending on specific mission or environment parameters (populated areas, weather, icing or contrail-prone situations, etc.). For example, the next generation flight management systems for fixed wing aircraft and helicopters will take into account the perceived noise as one of the flight optimisation constraints.
- Possibility to introduce new criteria for global optimisation without redeveloping and recertifying the flight management systems.
- Automation of flight in all phases to secure the environmental gains made possible by the system.

In addition, the systemic improvements initiated by SESAR and NextGen will call for new functions and capabilities geared towards environmental or performance objectives, and for flight optimisation in all conditions, flight safety, crew awareness and efficiency, better maintenance, reduced cost of operations and higher efficiency. The Systems ITD in Clean Sky 2 will address this through the following actions:

- Work on specific topics and technologies to design and develop individual equipment and systems and demonstrate them in local test benches and integrated demonstrators (up toTRL5). The main domains to be addressed are cockpit environment and mission management, computing platform and networks, innovative wing systems, landing gears and electrical systems.

- Customization, integration and maturation of these individual systems and equipment in IADP demonstrators. This will enable full integrated demonstrations and assessment of benefits in representative conditions.
- Transverse actions will also be defined to mature processes and technologies with potential impact on all systems, either during development or operational use.

Description of activities 2014-2015

▪ **Work Package 0**

The management activities will set the frame and control the running activities and manage in parallel the launch of the first CP call and definition of CfPs for 2015.

▪ **Work Package 1**

2014 & 2015 work for WP1 “Avionics Extended Cockpit” will mostly address definition activities, mostly of preparatory and organizational nature:

- Definition of main functions and flight management features to be featured in the ITD-level demonstration of extended cockpit. Identification of additional / alternative candidate functions, probably via open calls for partners/core partners.
- Definition of the overall functional architecture to host planned activities and accommodate additional contributions to be integrated in the main demo: target platform, format and high-level principles, down-selection and insertion process.
- Early work with airframers (Large, Regional, Bizjet, Rotorcraft, Small regional)
 - Work on aircraft-level requirements from airframers
 - Mapping of expectations and selection of minimum functional content for demo platform.
 - Identification of functionalities not selected in the mailine demonstration, possibly to be accommodated alternatively, via CP, CfP.
 - Identification of synergies, common systems/subsystems addressing the needs of two or more airframers.
 - Work on high-level constraints/requirements for future IADP integration and high-level specification of future customization.
- High-level specification of the common, ITD-level physical demonstrator of the extended cockpit: number of screens, head-up philosophy, main IHS means.
- Definition of needed environment, support, tools for the extended cockpit demo: simulators, minimum operational environment.
- High-level specification of additional demos to address specific needs for functions or stringent cockpit constraints.

- Identification of existing / planned building blocks in the field of Integrated Modular Architecture and networks.. Down-selection of best candidates, definition of a very high-level target architecture for extended cockpit demo platform & networks.
- Early work with airframers (Large, Regional, Bizjet, Rotorcraft, Small regional)
 - Work on aircraft-level requirements from airframers
 - Mapping of expectations and selection of minimum functional content for demo platform.
 - Evaluation of transverse, synergetical issues: scalability, re-use.
 - Identification of technologies not selected in the mainline demonstrator, possibly to be accommodated alternatively, via CP, CFP.
 - Work on high-level constraints/requirements for future IADP integration and high-level specification of future customization.
- Definition of needed environment, support, tools for the extended cockpit demo: simulators, minimum operational environment.
- High-level specification of additional demos to address specific needs for technologies or stringent cockpit constraints.

In 2014 & 2015, an inventory of existing work in related collaborative R&D projects will be established, and added value through synergies and synchronization will be sought. This should lead either to integration and maturation of other projects' results (typically L1 or L2) in the larger CS2 demonstrations, or to a high-level alignment of CS2 developments and demonstrations with system-level policies (SESAR results).

While most of the activity in the period should be performed by Systems leaders, some early assessment and definition Core Partner work will start as well (2015). Partner's activities may also take place for advanced identification of innovative concepts.

▪ **Work Package 2**

2014 & 2015 work for WP2 "Cabin & Cargo Systems" will lead to the publication of one or two strategic topics for Core Partner's contributions in the fields of power systems for cabin (self-sufficient cabin, energy storage ...), cargo systems, and transverse redefinition of cabin electronics in an IMA-like approach. Specifications and early developments will be led by the Core Partners selected, and should start by the end of 2015.

▪ **Work Package 3**

For regional and large aircraft demonstrators, the work will start in the second semester of 2014, except for the structure integrated system where partner participation is expected.

The smart integrated wing systems architecture design will begin in 2014 with trade-off studies and will be further elaborated and matured in 2015 and 2016, integrating Partners contribution and expertise.

In the meantime, the first development step will replace all engine driven pumps (EDPs) by generators but keep the hydraulic actuators as a well proven technology for flight control.

The architecture is based on new control technologies and cooling concepts which represents the next step of such Hydraulic Power Packages (HPPs). The design activities, conducted in collaboration with IADP LPA Leader will start in the second half of 2014, with a TRL5 target in 2016.

In Parallel, sensors and power electronics technology bricks will be matured internally, and continue with the technical contribution out of the calls for proposal.

Concerning the demonstration focusing on regional aircraft Flight Control Systems (FCS) application, the activities in 2014 will start with systems and real time architecture studies, as well as preliminary activity on electrical network for energy and data distribution. The activities regarding the technology bricks (sensors, actuators, etc.) will start in 2015.

▪ **Work Package 4 (depending on re-evaluation outcome)**

The Landing Gear systems activities are organized around different technologies pillars which are the actuation, the green taxiing and the short TAT brake cooling.

For the Main Landing Gears (MLG), activities regarding electrical actuation will start in 2014, with a down selection of the preferred electrical MLG extension retraction system. Definition of the specifications for the braking EMA components will also take place.

In 2015, generation of specifications for second generation of Green Taxiing System at integration level and at components level based on first generation performance level and targeted improvements will be performed; it would help to decrease the noise and improve local air quality (LAQ) on ground by taxiing the aircraft while having the main engines shut down. Similar activity for short Turn Around Time (TAT) braking system will be done, based on current research activities at low TRL levels.

The Nose Landing Gear (NLG) development activities will focus on Electro-Hydraulic Actuation (EHA), where in 2014 firstly several trade studies will be carried out to define project baseline configuration.

The preliminary design starts with full system and equipment design activities will run in 2014. The following Preliminary Design Review (PDR) is planned for January 2015, followed by the detailed design phase.

During the detailed design phase the final configuration of system design and equipment design will target a TRL3 review in May 2015 and a Detailed Design Review (DDR) in September 2015. The successful execution of the DDR will then start the prototype manufacturing.

The Tiltrotor landing gear system activities will start in the second half of 2014 jointly with IADP Rotorcraft leader Agusta Westland by the definition of the complete system and the preliminary concept and design phases. Then, the partner content will be defined and the calls will be prepared.

▪ **Work Package 5 (depending on re-evaluation outcome)**

The electrical chain distribution activities to start in 2014 will be organized around the power generation and two distribution architectures.

Within power generation demonstrators, technologies bricks for AC and DC network generators and also generator control unit (GCU) are going to be evaluated to expect a TRL 4 level at the beginning of 2015, followed by the organization of TRL5 prototypes development. In parallel, collaboration with IADP Airframers will be initiated to establish A/C conditions and specifically requirements and also tests plan.

Concerning to conversion demonstrators, TRL4 level milestone is planned in the year of 2015 and in parallel, collaborations with IADP Airframers to define System specifications are planned to occur frozen A/C specification in the middle of the year 2015. A selection of dedicated technologies is also planned in regard to these specifications and the performances of the TRL4 demonstrators. Technology and maturity road maps on energy storage with core partner collaboration are also planned in the year 2015.

For the Innovative Electrical Network (IEN) decentralized architecture concept, the scenario definition, dealing with the usage scenarios based on end users' needs (number of loads, location, nominal power, redundancy needed, etc.) will start in 2014. In a second time, activities will be launched in 2015 for functional need / topology selection and technological block developments.

At the end of 2014, analyze and evaluation the performances of power management center developed in Clean Sky are planned. Further designs for regional, business jet and large aircraft will leverage on these results and will begin in the year of 2015 with the definition of next generation of power management center, these tasks will be made with collaboration of the IADP Airframers and core partner.

The new electrical network HVDC performances have to be consolidated and validated through tests with representative hardware coming from Members and Partners. An electrical network simulation is necessary to set-up the equipment specification and then to extrapolate the test results to full aircraft architecture. In the 2 first years, the task consists in defining the key equipment demonstrators and associated verification and validation plans in relation with the partners:

- Enhanced architecture : the task consists in relation with the other work packages to select the right new technology
- Validation plan: the task consists in elaborating the road map for the project

▪ **Work Package 6**

The major loads work package regroups the main electrical loads on the aircraft, which is a wide set of activities. In 2014, the resources will be mainly charged on design activities for the E-ECS for Large Passenger Aircraft, on electrothermal wing ice protection system and on electrical motors.

In 2014 and 2015, a trade-off on new electrical ECS architectures for a single-aisle application, extended to thermal management and with Trans ATA consideration, will be carried out based on experience gained on Clean Sky studies and demonstrations.

This study will enable to define an E-ECS architecture optimized with respect to system impact on weight and power consumption, reliability, drag reduction and enhanced engine power efficiency.

Moreover, Liebherr will pursue in 2015 the maturity improvement of the major components like turbomachines, power electronics and centrifugal VCS compressor.

These developments will pave the way for the development of an airworthy full-scale E-ECS demonstrator (from 2016).

For Wing ice Protection System, the initial developments planned in 2015 will focus on the design of an optimized architecture for large aircraft based on preliminary work performed in JTI Clean-Sky and with focus on performance, weight, reliability and maintainability. The Ice protection strategy will be refined according to optimize the power consumption.

In the year of 2015, activities are planned to reach TRL3 level for weight-optimized reliable motor control strategies at hardware and software levels. In parallel, technologies road map is planned to perform electrical motor and to specify the next generation of electrical motor and control motor.

In 2014/15 COPPER BIRD® will support the design of demonstrators, providing experience, lessons learnt based on Clean Sky programme, and constraints in test possibility. After demonstrator's PDR the design of test means adaptation, choice of partners or subcontractors will begin.

▪ **Work Package 7**

The activities of the Small Air Transport (SAT) group are detailed in the SAT Work Plan.

Milestones and Deliverables for 2014-2015

Milestones

WP0 – ITD Management

- ITD Systems Kick-Off
- ITD Systems Annual review

WP1 – Extended cockpit preparation

- Launch of Extended Cockpit Demonstrator specification
- Validation of Extended cockpit architecture

WP3 – Smart integrated wing for large aircraft

- Roadmap of technologies and integration
- Preliminary wing systems architecture available

WP4 – Full Electrical Actuation System for Main Landing Gears

- Launch of MLG Electrical LGERS demonstrator design
- Launch of MLG Braking EMA components design

WP4 – Green Taxiing

- Launch of specification phase for second generation of Green Taxiing Systems

WP4 – Short TAT braking system

- Launch of specification phase for future short TAT braking system

WP4 – Tiltrotor Landing Gear System

- Partner selection
- Prel. System Spec. release
- IDR

WP5 – Power Generation

- DGPU requirements for RA and LA IADP

WP6 – Electrical ECS

- Selection of E-ECS architecture

Deliverables

WP0 – ITD Management

- Topics definition for CP
- Topics definition for CfPs to be launched in 2015
- Work plan 2015-2016

WP1 – Extended cockpit preparation

- Initial list of functions for down-selection
- Airframers requirements
- List of ad hoc demonstrators planned in WP1
- Overall definition of extended cockpit (Displays)
- Overall definition of extended cockpit (functions & FMS)
- Initial list of architectures for down-selection
- Airframers requirements
- List of ad hoc demonstrators planned in WP2
- List of target building blocks
- Work plan 2015-2016
- Overall definition of extended cockpit (Architecture)
- Overall definition of extended cockpit (Hardware)

WP2 – Cabin & cargo systems

- Statement of work and demonstrator description

WP3 – Smart integrated wing for large aircraft

- Wing system architecture for large aircraft
- Wing systems definition to fit architecture

- Joint system/structure architecture
- Business case analysis of structure integrated system
- Design criteria for autonomous Electro-Hydrostatic Actuation
- Topics descriptions for other wing systems
- Smart integrated wing test rig specifications
- Smart integrated wing test rig preliminary design

WP3 – Innovative electrical wing for regional aircraft

- Preliminary architectures specification
- Preliminary components specification
- Test means specification

WP4 – Full Electrical Actuation System for Main Landing Gears

- Selection of MLG Electrical LGERS architecture to be evaluated
- Definition of MLG Electrical LGERS prototype
- Specification of MLG Braking EMA components

WP4 – Green Taxiing

- Specification for second generation Green Taxiing systems

WP4 – Short TAT braking system

- Specification of future short TAT braking system

WP4 – Nose Landing Gear

- Trade Study Results for NLG Actuation
- Trade Study Results for NLG Installation
- System Description Document 01/2015
- System V&V Plan

WP4 – Tiltrotor Landing Gear System

- RFP`s
- System Design Description
- Requirements List MLG/ NLG structure
- Design Description MLG/ NLG structure
- Requirements List actuation
- Design Description actuation
- RFP for BWT/BC
- Design Description for BWT/BC
- Trade Study Report
- System Design Description

WP5 – Power Generation

- System requirements defined with IADP Airframers for the needs of power conversion
- DGPU requirements for RA and LPA IADP

WP5 – Innovative electrical network & Power management center

- Next step toward MEA technologies for the electrical network (draft)

WP5 – Innovative electrical network

- Use case scenario definition (1st step)

WP5 – Power management center

- Specification for the next generation of power management center for RA, business jet and LA aircraft

WP6 – Electrical ECS

- Specification of E-ECS components
- V&V plan

WP6 – Electrothermal WIPS

- Optimized architecture for Large aircraft
- Design and development of a ground demonstrator for performance tests in icing Wind Tunnel
- Performance test report (IWT)

Implementation

The activities in the Systems ITD will be performed following the general principles of the Clean Sky 2 membership and participation.

Thales and Liebherr, as the ITD Leaders, will perform the main activities related to the technology development and demonstration in the ITD. Significant part of the work will be performed by Core Partners, supporting the ITD leader in its activities. Finally, another part of the activities will be performed by Partners through Calls for Proposals for dedicated tasks.

Thales and Liebherr, as the ITD Leaders, will sign the one Grant Agreement for Members (GAM) in order to perform the work. This GAM will cover all the work of the Members in this ITD. The Core Partners are selected through open Calls for Core Partners and the retained applicants will accede to the existing Grant Agreement for Members. Partners will be selected at a later stage through Calls for Proposals and will be signing the Grant Agreement for Partners. They will be linked to the ITD activities through the Coordination Agreement.

The following topics are opened for the first call for Core Partners:

JTI-CS2-2014-CPW01-SYS	
JTI-CS2-2014-CPW01-SYS-02-01	Power Electronics and Electrical Drives
JTI-CS2-2014-CPW01-SYS-03-01	Model, Tools, Simulation and Integration

Detailed description of the topics is provided in ***Annex I - 1st Call for Core-Partners: List and Full Description of Strategic Topics.***

Type of action: *[Innovation action, funding rate 70%¹²]*

¹² Research organisations may apply for the 100% funding rate in accordance with H2020 rules

9.7. SMALL AIR TRANSPORT TRANSVERSE ACTIVITY

The SAT Initiative proposed in *Clean Sky 2* represents the R&T interests of European manufacturers of small aircraft used for passenger transport (up to 19 passengers) and for cargo transport, belonging to EASA's CS-23 regulatory base. This will include dozens of industrial companies (many of which SMEs), research centers and universities. The New Member States industries feature strongly in this market sector. The community covers the full supply chain, i.e. aircraft integrators, engine and systems manufacturers and research organisations. The approach builds on accomplished or running FP6/FP7 projects. Key areas of societal benefit that will be addressed are:

- Multimodality and passenger choice;
- More safe and more efficient small aircraft operations;
- Lower environmental impact (noise, fuel, energy);
- Revitalization of the European small aircraft industry.

To date, most key technologies for the future small aircraft have reached an intermediate level of maturity (TRL3-4). They need further research and experimental demonstration to reach a maturity level of TRL5 or TRL6. The aircraft and systems manufacturers involved in SAT propose to develop, validate and integrate key technologies on dedicated ground demonstrators and flying aircraft demonstrators at an ITD level up to TRL6. The activity will be performed within the *Clean Sky 2* ITDs for Airframe, Engines and Systems with an aim to making the best use of synergies with the other segments of aeronautical design, with strong co-ordinating and transversally integrating leadership from within a major WP in Airframe ITD.

Description of activities 2014-2015

The activities in 2014 will mainly consist of the initializing work on the definitions for the first set of technology developments and demonstrators, and selection of the first Core Partners. The high level objectives, definitions and requirements for those demonstrators will be confirmed and the overall SAT CS2 technical description will be improved.

The planning of CS2 programme technical activities will be matured and precised. The interfacing of SAT activities within all three ITD's Airframe, Engines and Systems will be fleshed out. In parallel the definition of synergies between technical activities of SAT and different IADP's and TAs will be initiated.

The technical description and the scope of the work of key Core Partners will be finalized, enabling a proper Core Partner selection process. After the successful selection of Core Partners, technical descriptions will be discussed in order to define planned activities of the Core Partners. Improvement of the Work Plan based on the Core Partner's activities will be initialized.

These activities will continue in 2015. In cooperation with selected Core Partners the definitions of selected concepts and technologies will be consolidated. The definition of reference aircraft will be defined.

- **ITD Airframe**

WP 0.2B – Small Air Transport Overall A/C Design & Configuration Management

Transversal coordination activity within SAT group will start. The interaction and interfaces with Technological Evaluator TA and inputs/outputs will be agreed. In 2015 activity regarding “reference aircraft” definitions will start, with the focus on performance, transport capabilities and the most important actual costs of a recent aircraft type in the 19 seat commuter class. Reference aircraft should be an existing platform of “best in class” current service aircraft.

WP B 1.2 - Optimized Composite Structures

The start of activities is strongly dependent on the timeframe for the Core Partner selection. It is assumed that WPs will be managed by selected CP and technical content will be elaborated by CPs. Expected activities in 2014 will be focus on preparation of CP selection in 2nd wave.

Activities in 2015 will be focused on defining the strategies of selection, development and application of suitable Out of Autoclave (OOA) composite production methodologies for the target demonstrator of a small aircraft wing box. The focus for the selection will be on the cost efficient production methodologies with reduction of number of components, more automation and higher process stability compared to wet laminate production methodology. Specific zones of the wing box with different structural requirements will be defined and suitable raw materials (matrix, carbon/fiber glass layer) and/or prepregs will be selected in 2015.

Coupon testing will start in 2016. The first CfP are planned for 2016.

WP B 2.3 – High Lift Wing (SAT)

The activities in 2014 of this WP will focus on the definition of State of the Art of generally used high lift devices at the 19 seater commuter class. In 2015 will be initialized process of definition of requirements of HLW for 19 seater with focus on simple, light weight and cost effective system. Approaches of leading edge/trailing edge devices will be considered for targeted short take-off and landing operations. Set of demonstrators will be defined – wind tunnel models. Trade off study will be done, selected technology will be considered and initial design work started.

WP B 3.4 – Advanced integration of systems in small a/c

The activities of this WP will focus on the definition of demonstrators, with close interaction with ITD Systems SAT Work packages. Technologies developed in Systems WP's will be integrated. Activities in 2014 will be focused on identification of proper flying/ground demonstrators. Demonstration activities from Systems WPs are expected to be covered by

leaders for S1 (health monitoring) S2 (more electric), and S5 (cabin) and selected Core partners S3 (fly by wire) and S4 (cockpit).

Selection of proper Core partners with ability to demonstrate selected technologies (fly-by-wire and cockpit) is a key element. In the 2014 will be initialized works on technical description of demonstrators and overall planning of demonstrator testing in interaction with selection of Core partner for cockpit in the first wave and during the 2015 the selection of core partner for fly by wire in the second wave .

WP B 3.5 - More Affordable Small a/c Manufacturing

The activities in 2014 of this WP will be focused on the trade-off study which will consolidate the orientations of automation towards targeted low costs and multidisciplinary use (such as boring, reaming, riveting and optical inspection) for “nest” join configuration. Works on the high level description of technology requirements will be initialized. Analysing of usage Rapid prototyping technologies in aircraft production will start. Key factor will be preparation of Core partners’ selection in 2nd wave for demonstration of automated assembling processes (longitudinal joints configuration) with multidisciplinary usage in low volume production.

In 2015 will continue works on the technology requirements and start design works on new concepts of automated assembling. Initial specification of demonstrators will be set in cooperation with selected Core Partners. The first CfP are planned for 2016.

▪ **ITD Engines**

WP E.1 - Reliable and more efficient operation of small turbine engines

The activities in 2014 will mainly consist in initiating the definition works of the first set of Engine ITD SAT Small Turboprops technologies developments and demonstration for engine components (High performance gas generator, Enhanced power turbine, Reduction gearbox and low noise propellers with integrated control system), leading to the high level description of objectives and requirements for those demonstrators.

Based on a successful selection of Engine ITD core partner in Wave 1, those activities will be continued in 2015 with inserting analysis from engaged Core Partner, with the target to achieve the preliminary definition of first scheduled demonstrators. Trade-offs analysis will consolidate the definition of selected engine components material and concept. Behaviour analysis will support the study of advanced Engine components specification phase to be initiated in 2015. The preliminary design of engine components will be launched.

WP E.3 - Light weight and fuel efficient diesel engines

The activities in 2014 will mainly consist in initiating the definition works by Leaders of the first set of Engine ITD Diesel technology developments and demonstration for engine components leading to the high level description of objectives and requirements for those demonstrators.

Those activities will be continued in 2015 with the target to achieve the preliminary definition of first scheduled demonstrators. Trade-offs analysis will consolidate the definition of selected engine components material and concept; behaviour analysis will support the study of advanced Engine components specification phase to be initiated in 2015.

▪ ITD Systems

WP S.1 - Efficient operation of small aircraft with affordable health monitoring systems

The activities in 2014 will mainly consist in initiating the definition works of the first set of technology developments and demonstration for Health monitoring in the area of: Structure Health Monitoring (SHM), Actuators with Health Monitoring and Solid State Power Controller (SSPC) with CBM, leading to the high level description of objectives and requirements for those demonstrators.

Based on a successful selection of the System ITD core partner in Wave 2, those activities will be continued in 2015 with inserting analysis from engaged Core Partner, with the target to achieve the preliminary definition of first scheduled demonstrators. Trade-offs analysis will consolidate the definition of selected components for demonstration and concept; behaviour analysis will support the study of SHM components specification phase to be initiated in 2015.

WP S.2 - More electric/electronic technologies for small aircraft

The activities in 2014 will mainly consist in initiating the definition works of the technology developments and demonstration for more electric systems.

Those activities will be continued in 2015 with inserting analysis from systems leaders, airframes leaders and engaged airframe ITD System Core Partner selected in Wave 2 for:

- Consolidation of selected system and architecture definition.
- First CfP in this area with the target to achieve the systems preliminary definition and the hardware development for demonstration.

WP S.3 - Fly-by-wire architecture for small aircraft

The activities in 2014 will mainly consist in initiating the definition works of the technology developments and demonstration for fly-by-wire.

Based on a successful selection of the Core partner in Wave 3, those activities will be continued in 2016 with inserting analysis from systems leaders, airframes leaders and engaged airframe Core Partner for:

- Consolidation of selected system and architecture definition.
- First CfP in this area with the target to achieve the systems preliminary definition and the hardware development for demonstration.

WP S.4 - Affordable SESAR operation, modern cockpit and avionic solutions for small a/c

The activities in 2014 will mainly consist in initiating the definition works of the technology developments and demonstration for modern cockpit with overview of relevant regulations and the formulation of recommendations to support the vision of SAT

Those activities will be continued in 2015 with inserting analysis from systems leaders, airframes leaders and engaged airframe Core Partner for:

- Consolidation of selected system and architecture definition.
- First CfP in this area with the target to achieve the systems preliminary definition and the hardware development for demonstration.

WP S.5 - Comfortable and safe cabin for small aircraft

The activities will focus on defining the strategies of selection, development and application of new passive multifunctional materials and active insulation materials in 2014. The first CfP in this area are planned to 2015. Analytical tools for prediction of acoustic environment during passive/active damping will be overviewed and the analytical environment will be settled in 2014. Selection of suitable aerospace materials for their dynamic properties investigation will be done in 2014 with the first CfP for coupon testing in 2015.

Milestones and Deliverables for 2014-2015

Major milestones planned for 2014:

- Selection of the Core Partners in First Wave for planned Core Partners activities in, WP B 3.4 (cockpit), and WP E.1
- Initiation of technology development for automated assembling WP B 3.5 and initial works on the definition of new materials/technologies in WP S.5

Major deliverables planned for 2014:

- High level description of objectives and requirements of Engine and Cockpit Systems demonstrators

Major milestones planned for 2015:

- Selection of the next batch of Core Partners in airframe (composite WPB1.2 and metallic WP B3.5), System integration (WP B3.4 fly by wire), Systems (S1, S2 more electric) , System (S4 cockpit)
- Preparation of CfP
- Initialization of technology developments in airframe, , composite structures
- Consolidation of selected system and architecture definition with contribution of selected Core Partners
- Airframe, Engine and Systems ITD Annual Review

Major deliverables planned for 2015:

- Concept guidelines of initial demonstrators in Airframe, Engines and Systems
 - First turbine engine concept, specification of systems and subsystems
- Updated work plan with inputs of selected Core partners
- Technical specifications for the systems to be included in demonstrators

Implementation

The activities in the Small Air Transport Transverse Activity (TA) will be performed following the general principles of the Clean Sky 2 membership and participation.

Piaggio and Evektor, as the TA Leaders, will perform the main activities related to the technology development and demonstration in the TA. Significant part of the work will be performed by Core Partners, supporting the TA leader in its activities. Finally, another part of the activities will be performed by Partners through Calls for Proposals for dedicated tasks.

Piaggio and Evektor, as the TA Leaders, will sign the one Grant Agreement for Members (GAM) in order to perform the work. This GAM will cover all the work of the Members in this TA. The Core Partners are selected through open Calls for Core Partners and the retained applicants will accede to the existing Grant Agreement for Members. Partners will be selected at a later stage through Calls for Proposals and will be signing the Grant Agreement for Partners. They will be linked to the TA activities through the Coordination Agreement.

The following topics are opened for the first call for Core Partners:

JTI-CS2-2014-CPW01-ENG	
JTI-CS2-2014-CPW01-ENG-04-01	More advanced and efficient small turbine engines for SAT market

Detailed description of the topics is provided in ***Annex I - 1st Call for Core-Partners: List and Full Description of Strategic Topics.***

Type of action: *[Innovation action, funding rate 70%¹³]*

¹³ Research organisations may apply for the 100% funding rate in accordance with H2020 rules

9.8. ECO DESIGN TRANSVERSE ACTIVITY

Since the beginning of Clean Sky Programme, hundreds of partners and technologies have risen to the challenges of Eco-Design for Airframe - EDA and ECO-Design for Systems – EDS, but all confine in a small vertical activity definition. A bigger transversal playing field, namely ECO-Design Transversal Activity, is necessary and the opening to apply the technology from the lab through the integration to complete component application on aircraft level is essential.

Eco-Design will co-ordinate research geared toward high (European) eco-compliance in air vehicles, over their product life. As transverse activity it profit from activity developed in the frame of Clean Sky Eco design ITD. Eco Design in Clean Sky 2 is based on two domain concepts, namely:

The **Eco-Design Analysis (EDAS)** activity where all pillars of life value are addressed, beyond the conventional “cradle to grave” philosophy, to stimulate better re-use options and new, best practice service options, embracing all the supply chain and SPD’s players priority. Eco-Design Analysis, directly linked to the development of advanced Life Cycle Assessment tools and methodologies, is a knowledge and responsibility empowerment approach, addressing widened stakeholder interests and enabling a better grasp of the full domain of ground pollution issues.

The **Vehicle Ecological Economic Synergy (VEES)** activity is driven from Materials, Processes & Resources (MPR) innovations, from the assimilation of cooperative modules from the SPD demonstrators with an adaptive Eco Hybrid Platform (EHP). This is “LCA+” (Life Cycle Analysis-plus) design driven in line to develop Design for Environment (DfE) vision, and is an open platform on the level of complete vehicles. It ensures a collective vision to enhance the SPD technology streams.

Eco design TA activity is geared toward compliance on quality, repeatability, and recommendations for ecological and economic improvements.

The ECO-Design Transversal Activity will support and interact with the other ITDs and IADPs by basically providing methodologies for Materials, Processes and Resources. Airframe and LPA represent the backbone of the technologies development, which will be then implemented at vehicle level also in the biz and regional demonstrators. ECO-Design activity will bring on board stronger activities from Systems and Engines ITDs compared to Clean Sky. The management will support all necessary interface requirements and will foster not only technical activities within the ITDs but also collaborative activities amongst ITDs and IADPs.

Description of activities

The Eco-Design activity has a *baseline*, *mainline* and *top level delivery* basis. This characterises the interactions with the SPDs and through them the output to the TE.

Work units represents the core of the activity through a proper and defined collaboration to be established with Eco-Design Life and REcycle disciplines (MPR, production, end of life) and SPDs.

▪ Baseline delivery

The *baseline* annotates the take-up of technologies from an eco-innovation angle for the benefit of improving SPD activities either by specific or general value issues. The main duty for this stands out through the **Eco-Design Life and REcycle** theme reference which is an orientation for current and forward looking technology pools.

It is important to note that the SPDs have addressed strong *technology streams*. These have a component / parts / system and specific vehicle orientation. Eco-Design unifies the effort aimed to specific clean technology and *process improvement* through the following main disciplines:

- Next Generation Life Scoping and Identification Strategy
- Materials, Processes and Resources (MPR)
- Manufacture/ Production
- Service to component and System (MRO, financing, accounting, storage, inside-outside gate processes, alt. parts/ COTS material flow, logistics)
- Re-Use Phase
- End of Life
- Integration/ Field Assembly-Disassembly- Separation
- Alternative Sectoral Applications
- Use Phase (complimentary reference access between TE and Eco Design: flight physics and operations of block time versus ground phase impact of eco design)

To pursue the effort in Clean Sky, new *life technology value* approaches are envisaged to ensure fresh technology alternatives are made available. This baseline can grow and develop continued improvement also through competitive calls to be defined in scope.

▪ Mainline delivery

The '*mainline*' *delivery*' is addressed by the coordinated impact orientation agreed with the SPD and to be developed in the early phases of the programme; obviously different vehicles, systems will have a different weighted approach depending on current developments. This is mostly accomplished by selected allocation of identified *Eco-Design work units into the SPD-WP-plot*, supported by *Eco-Design analysis*.

Eco-Design needs real life technology ensembles, and is dependent on a concept to track complete processes, complete vehicles and complete architectures. This can be formed on

building blocks (as accessible *modules*) from the perimeter of Eco-Design in the respective SPD. Eco-Design Analysis then validates the vehicle-level life cycle impact.

These concepts will not be able to contain, since the beginning, all the virtues of life cycle variables and working towards an optimum; this has to be grown in realistically without any technology lock-in on any side. A *coordinated forward looking approach* has to be found, combining best synergies to get the respective full air-vehicle picture, working with high performance issues.

Eco-Design will define an **Eco Hybrid Platform (EHP)**, in view of a **Design for Environment (DfE)** vision, which is totally *life cycle plus* (LCA+) driven in its design to ensure transversal purpose. This would be a major advance from the present Eco-Design delivery.

- Top level delivery

The *top level delivery* pertains to the hand-in-hand delivery through-put of Eco-Design with the ITD/ IADP benefit analysis to the needs of the Technology Evaluator, to complement its global socio-economic demand analysis.

Generally, but not exclusively, this will be based on results in a *big impact technology pathway (BITP)* format which will be served also to the examination of industrialisation scoping of the ITD/ IADPs.

In conjunction with that scoping, Eco-Design will also deliver the respective socio-economic derivatives, including work effort improvements (e.g. through human interface assisted automation in production).

Milestones and Deliverables for 2014-2015

Eco design transversal activity major outcomes in the first 2 years (2014-15) are summarized in the following table.

In **2014** the set-up of the transversal activity will be managed together with the understanding and definition of requirements from SPDs in line with technology stream contribution to be assessed from a life cycle's perspective. Initial activities will concern definition of all the 3 activity delivery levels and ways of interaction with SPDs/TE.

Sub-teams to support the collaborative EDAS and VEES issues will be set up that continuously monitor, optimise links and responses and submit recommendations to the Eco Design TA committee. The Work units' definition needs to be assessed through a dedicated deliverables. In 2014 most technical activities are performed in the frame of T1 where the scoping-screening-identification giving Life Information Technologies (LIFT) is addressed.

Other tasks are foreseen and are further described in the table below.

A first batch of calls is intended to be proposed at mainline level to support the TA in line with the agreed scope.

In **2015** the program will develop, extending to the other main tasks to define the team work, interactions, technology scoping and LCA tools new requirements, including economics, financing processes. Top level activity on the socio-economic derivative along with the economic harmonisation concept (link with TE and ITD/ IADP respectively) will be then activated as well. A second batch of CFP partners will be selected to support the activities.

LCA & MPR-workshops are organized during these years, in view of dissemination and public feedback. Complementarity and excellence issues for the topics' proposals will be supported through the Eco Design TA coordination committee.

Major milestones planned for 2014-2015:

- First Eco Design CFP topics definition and launch
- 1st Coordination Steering Committee launched on the remit of the GB and CS Programme Office; Importantly, sub working groups for Eco-Design Analysis and Vehicle Ecological Economic Synergy are set up
- Description of Work reference for the first major period 2014 to 2017 is completed with consensus through the coordination steering committee
- Selection of the first batch of Partners
- Selection of the second batch of Partners
- Integration of the future CS GMM requirements for the TA
- Work-units set-up in the project data management system
- Clean Sky Materials, Processes & Resources Data Base in secured augmented functionality
- Eco (compliance) matrix for EH proposal completed as input to ITD/ IADP
- Eco Statement, now in hands of TA
- ES 2015 in the advanced scope of Clean Sky 2 – see global targets.

Major deliverables planned for 2014-2015:

- High level description of each SPD objectives and requirements prioritisation as input
- Arbitration of economic targets and expected LCA/flow logic methodologies
- Tech/Work-units definition and collocation of interactions: Work units-Work correspondence table maturation c.f. JTP
- Clean Sky Major Workshop “MPR and LCA” State of the Art and New Frontiers Participant socio-economic “check-in check out” tableau definition
- Consolidation of objectives and requirements
- Progress on LCA/flow logic methodologies needs
- Clean Sky Major Workshop “MPR and LCA” State of the Art and New Frontiers
- Second Eco Design CFP topics definition and launch
- Eco tasks scope definition per SPD
- LIFT Technology description and new frontiers
- Effects on CS Materials, Processes and Resources(MPR) Data Base functionality
- LIFT-interfaces definition
- TA detailed plan and master technical GANTT

- First deliveries of the selected CfP projects (state of the art plus socio-economic check-in)
- First down selection reports of conceptually validated technologies on selected components
- LIFT-LCA tools interfaces, tracing results by technology examples
- Eco Hybrid platforms scoping and definition
- ECOTech scoping and definition
- First deliveries of the complimentary member contributions
- Concept of key performance Indices maps, foot prints, system eco categories, Regulation hotspots wrt. REACH etc.
- First analysis of ITD / IADP configurations proposed
- Conception of new architectures beyond the current technologies
- Eco architecture scoping
- Strategy paper eco design and systems
- Strategy paper eco design and airframe
- Review of Eco Design ITD high TRL population for application of the new didactic Eco Design eco-compliance population
- validation of new process impacts with first available configuration(s) from the ITD/ IADP
- First SOA tools and substances in metal versus composites major reference manufactory process chain ensemble measured for LCA inputs
- Eco statements planning and global output for CS 2
- Definition and first traced values for the RRQ, GPP and SES key Performance Indicators socio-economic charter
- Input of SPD ecolonomic analysis approach, giving at least the SLCA (Simplified LCA) reference
- Provision of Supplier LCA module
- SWOT analysis of Eco ITD LCA contributing to LCA+ assets
- Tools requirements LCA and ecolonomic harmonisation with respect to the respective user benefit analysis of each major integrator

Implementation

The activities in the Eco Design Transverse Activity (TA) will be performed following the general principles of the Clean Sky 2 membership and participation.

Fraunhofer, as the TA Leader, will perform the main activities related to the technology development and demonstration in the TA. Significant part of the work will be performed by Core Partners, supporting the TA leader in its activities. Finally, another part of the activities will be performed by Partners through Calls for Proposals for dedicated tasks.

Fraunhofer, as the TA Leader, will sign the one Grant Agreement for Members (GAM) in order to perform the work. This GAM will cover all the work of the Members in this TA. The Core Partners are selected through open Calls for Core Partners and the retained applicants will accede to the existing Grant Agreement for Members. Partners will be selected at a later

stage through Calls for Proposals and will be signing the Grant Agreement for Partners. They will be linked to the TA activities through the Coordination Agreement.

There are no topics opened for the first call for Core Partners for this TA.

9.9. TECHNOLOGY EVALUATOR

A Technology and Impact Evaluation infrastructure is and remains an essential element within the Clean Sky JTI. Impact assessments evaluating the performance potential of the Clean Sky 2 technologies both at vehicle level and at relevant aggregate levels such as at Airport and ATS level, and currently focused on noise and emissions, will be retained. Where appropriate they will be expanded to other relevant environmental or societal impacts (e.g. mobility benefits or increased productivity).

For vehicle concepts arising from the IADPs, the core aircraft performance characteristics (at the so-called ‘mission level’) will be reported by the IADP and TE impact assessment will focus on aggregate levels. For those Clean Sky 2 ITDs technologies not feeding into an IADP aircraft model, the TE will build up its own Mission Level assessment capability, also to assess innovative long term aircraft configurations. Thus, an aircraft-level synthesis of these results via ‘concept aircraft’ is possible and the respective ITD results can be shown at aircraft level and evaluated within the Airport and Air Transport System alongside the IADP results. In summary, the Technology Evaluator consists of three major tasks:

- Monitoring of *Clean Sky 2* achievements vs. defined environmental and societal objectives;
- Evaluation at Mission Level by integrating selected ITD outputs into concept aircraft / rotorcraft;
- Impact Assessments at Airport and ATS Level using IADPs and TEs concept aircraft / rotorcraft.

Description of activities

The 1st Clean Sky 2 TE assessment is foreseen for 2017. In that context the 2014-2015 Clean Sky 2 TE activities will be preparatory work in terms of the assessment and models input and output specifications. Preparation for TE concept aircraft modeling and Air Transport System (ATS) scenarios definition will also be done. The existing Clean 1 TE toolsuite will be reused. Organizational issues will also be dealt with (e.g. CFP and core partner definition).

Description of high level work packages 2014

WP1 TE scope and set up

The overall scope and set-up of CS2 TE is covered through WP1. WP1.1. will define the TE assessment metrics to be applied based on the IADP and ITD objectives in terms of environment, mobility and socio-economic aspects. Additionally the CS2 TE reference point will be defined for 2015 state of the art aircraft.

The TE inputs and outputs will be defined through WP1.2. This encompasses the inputs from the IADPs and ITDs and the outputs of the TE.

WP2 TE Interfacing with IADPs, ITDs and transversal activities

WP2 covers the interfacing between the TE and the three ITDs, namely Airframe, Engine and Systems, and the IADPs, namely Large Passenger Aircraft, Regional Aircraft and Fast Rotorcraft. In 2014 one meeting will be held for to discuss WP1 issues and deliverables. TE timing and integrated planning with IADPs and ITDs will be discussed and iterated based on the 2014-2015 foreseen CS2 activities.

Main milestones / deliverables 2014

Activities are planned to start in October 2014. Milestones will be those done through the WP2 “interfacing with IADPs, ITDs and transversal activities”. One meeting will be held in October to monitor and discuss the WP1 activity.

Two deliverables for 2014 are planned [D1 and D2]; see also the figure overleaf

- D1 will encompass the TE set-up, methodology and metrics as related to WP 1.1
- D2 will encompass the definition of the TE’s interfaces and inputs/outputs as related to WP 1.2

	<u>CS2 TE workplan 2014</u>	
	Deliverable	
WP 1	TE Scope and Set-up	deliverables
WP 1.1	Methodology for evaluation, impact assessment and interdependencies	
	Metrics/objectives	D 1
	Reference points	
WP 1.2	Definition of TE inputs and outputs	
	IADP inputs to TE	D 2
	ITD inputs to TE	
	TE outputs	
WP 2	TE interfacing with IADPs, ITDs and Transversal Activities	
	Regular 3 month meetings	

Description of high level work packages 2015

WP0 TE management

Possible CFP topic descriptions will be prepared by taking into account available expertise in Europe. The setup of the CS2 TE core team will be prepared.

WP1 TE scope and set up

The results of the 2014 deliverable will be updated for WP 1.1 and WP 1.2.

In WP1.3 consistency with SESAR and other projects like environmental CSAs in Horizon 2020 will be checked and discussed.

WP1.4 will specify a 1st version of the 2017 planned CS2 TE 1st assessment.

WP2 TE Interfacing with IADPs, ITDs and transversal activities

Four meetings are planned to discuss WP0, WP1, WP3 and WP5 issues and deliverables.

WP3 TE independent integration on Mission level

As recommended by external reviewers, a reinforced TE Mission Level modeling capability for aircraft will be developed in WP3. The goal is to allow the generation of TE aircraft models at a conceptual design level. This environment would be capable to take into account specific aspects of Airframe, Engine and Systems technologies. In coordination with ITDs a set of technologies will be defined as preparation for future TE concept aircraft modelling for 2035 and 2050 concept aircraft.

WP5 TE ATS impact assessment

The preparation of generic ATS airline scenarios and assessments will be started.

Main milestones and deliverables for 2015

Milestones will be the done through the WP2 “interfacing with IADPs, ITDs and transversal activities”. 4 meeting sessions will be held to monitor the progress of WP0, WP1, WP3 and WP5 activities and foreseen deliverables.

WP 0 TE management

- CFP topic description
- Core team topic description

WP 1 TE Scope and Set-up

- WP 1.1 Methodology for evaluation, impact assessment and interdependencies
 - Metrics/objectives update
 - Reference points update
- WP 1.2 Definition of TE inputs and outputs
 - IADP inputs to TE update
 - ITD inputs to TE update
 - TE outputs update
- WP 1.3 Consistency with respect to external projects
 - SESAR interaction and inputs on other projects (CSAs)
- WP 1.4 Global workflow
 - Overall Specification of 2017 assessment

WP 2 TE interfacing with IADPs, ITDs and TAs

- Regular 3 month meetings

WP 3 TE independent integration on mission levels

- WP 3.3 Innovative aircraft design

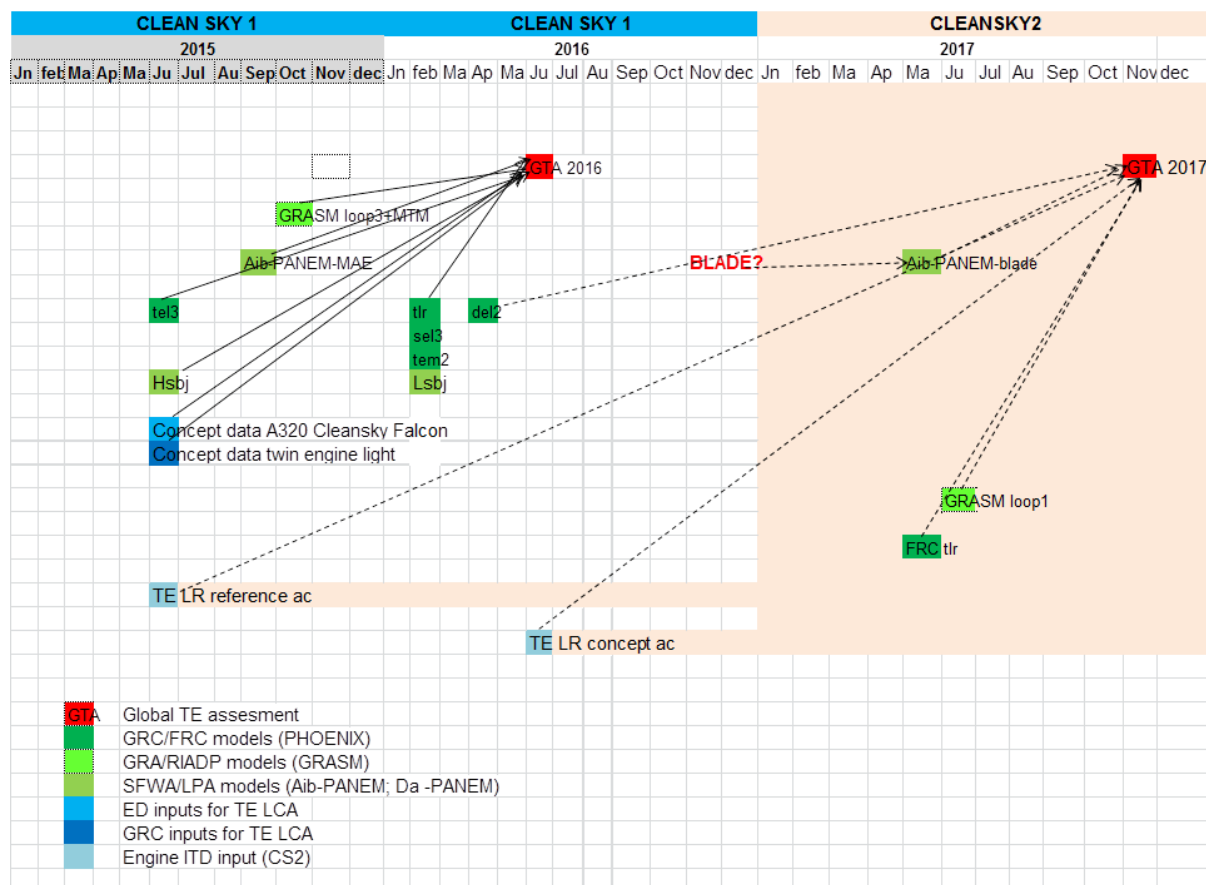
- TE aircraft model preparation: 2035/50

WP 5 TE ATS Impact assessments

- WP 5.1 Forecasts, Scenarios and Airport Capacity Constraints
 - ATS scenario preparation

Clean Sky TE / Clean Sky 2 TE transition

The figure below shows an excerpt of the transition from Clean Sky TE to Clean Sky 2 TE with respect to the 1st assessment for Clean Sky 2 TE in 2017. Some Clean Sky results will be taken over in the Clean Sky 2 TE 1st assessment as e.g. the outcomes of the BLADE test that is scheduled for the end of 2016. The last Clean Sky TE assessment is planned for mid of the year 2016. In parallel to Clean Sky TE Clean Sky 2 TE work will be performed on the TE concept aircraft modeling as shown here in the example of the long range aircraft model to be performed by the TE in cooperation and through inputs from the Clean Sky 2 engine ITD.



Implementation

The activities in the Technology evaluator Transverse Activity (TA) will be performed following the general principles of the Clean Sky 2 membership and participation.

DLR, as the TA Leader, will perform the main activities related to the technology development and demonstration in the TA. Significant part of the work will be performed by Core Partners, supporting the TA leader in its activities. Finally, another part of the activities will be performed by Partners through Calls for Proposals for dedicated tasks.

DLR, as the TA Leader, will sign the one Grant Agreement for Members (GAM) in order to perform the work. This GAM will cover all the work of the Members in this TA. The Core Partners are selected through open Calls for Core Partners and the retained applicants will accede to the existing Grant Agreement for Members. Partners will be selected at a later stage through Calls for Proposals and will be signing the Grant Agreement for Partners. They will be linked to the TA activities through the Coordination Agreement.

There are no topics opened for the first call for Core Partners for this TA.

10. CALL ACTIVITIES IN 2014-2015

10.1. Calls for Core Partners

Core Partners

The Core Partners will be Members of the JU and, with a strategic long-term commitment to the funding and implementation of the Programme, will perform strategic tasks and bring key capabilities to implement the Programme through the research actions in which they are involved.

More specifically, the Core Partners shall bring to the Programme the following:

- Strategic long-term commitment;
- Key competences/capabilities necessary to carry out strategic activities of the programme such as the development of major elements of one or several demonstrators (from the study to its final integration) and closely related to the needs as defined in the IADP/ITD;
- Significant level of in-kind contribution that is consistent with the indicative total value of each Topic and further activities which may be performed, where applicable, in the relevant IADP/ITD. The indicative average total value of a Topic for the selection of Core Partners will be approximately 10 M€ throughout the Programme.¹⁴

The activities to be carried out will address the following aspects:

- Technological research activities, reflecting the core activities of the programme, aimed at a significant advance beyond the established state-of-the-art, including scientific coordination;

¹⁴ This indicative average total topic value of 10M € is set in a way to achieve at global and individual level a real strategic contribution and level of investments of the Core Partners to the Programme in the light of the total budget of the Programme (1,755 B€), the level of in-kind contribution to the Programme to be brought by the Core Partners as Members of the CSJU (Article 4 of the Statutes) and the 30% maximum share of funding envisaged for Core Partners as set out in the CSJU Regulation. The value is indicative and is set also in view of selecting a total number of Core Partners which would fit with the work plans and management structures of the IADP/ITDs and with the governance structure of the CSJU. This may take the form of participation to the Steering Committees of the IADP/ITDs which require an effective and efficient decision-making process. Core partners as members of the CSJU shall also pay their respective contribution to the running costs of the JU – based on the percentage of their operational activity in the overall programme and will be expected to sign the funding agreement for members. The funding values shall not be confused with the total topic value. The funding value corresponds to the average funding calculated by the JU based on the experience in the Clean Sky programme. The final funding value per topic will entirely depend on the cost structure of the winning entity, the funding rate, and the scope of work proposed in their application.

- Direct contributions to building up integrated demonstrators, designed to prove the viability of new technologies that offer a potential economic advantage, up to TRL 6;
- Other contributing activities such as work package management, dissemination of research results and the preparation for their take-up and use, including knowledge management; and activities directly related to the protection of foreground.

The Core Partners will engage in performing the following tasks:

- Address the Strategic Topic for Core Partners and commit to its level of in-kind contributions by performing the activities defined in the topic and (providing) delivering the required deliverables in accordance with the specified schedule;
- Be responsible for a Level 1 or Level 2 Work Package in an IADP/ITD or TA
- Contribute to the management of demonstrators;
- Become a member of JU, commit to at application stage and endorse the Statutes of JU by signing an official letter of acceptance and a funding agreement for their proportion of the running costs of the JU;
- Contribute to the overall funding, objectives and implementation of the Programme in the relevant IADP/ITD;
- Act where appropriate as a Topic Manager in the Calls for Proposals of the relevant Work Package for which they are responsible, and consequently, be in charge of monitoring the activities of the relevant Partner(s) selected by the JU by the Calls for Proposals;
- Participate to the relevant Steering Committees of the IADP/ITD and be represented in the Governing Board of the JU
- Co-determine the direction of the Programme through its governance entitlements.

10.2. Definition of Strategic Topics

Core Partners will be selected on the basis of Strategic Topics for Core Partners which will be launched through the Calls for Core Partners. Applicants wishing to become Core Partners in the Clean Sky 2 Programme shall submit applications against one or more Topics describing their key capabilities and competences and a description of the work to be performed in response to the topics. The proposals will be evaluated and the highest ranked applications will be proposed for acceptance to the Governing Board and may be selected for funding by the JU.

The description of the Topic will define the key capabilities and capacity required to the applicants to implement the Programme in the relevant IADP/ITD area and the scope, goals and objectives of the activities to perform the topic.

The description of the overall Clean Sky 2 Programme is the “Joint Technical Programme [published by JU on the 27th of July]¹⁵ which may be regarded by the applicants to clarify the context of the topics within the overall strategic objectives of the Programme and the relevant IADP/ITD area.

The Strategic Topic descriptions are indicated in the Work Plan and in detail in the ***Annex I - 1st Call for Core-Partners: List and Full Description of Strategic Topics***.

Content of the Strategic Topic description:

- The name of the IADP/ITD to which the activity is linked;
- the key capabilities, operational capacity and competences required to implement the Programme (expertise, skills and track record) and to deal with the risks associated to the activity under the topic and the Programme area (both at IADP/ITD and applicant level);
- the proposed scope of work and activities outputs as required within the IADP/ITD;
- the name of the CS2 Leader opening the topic;
- an indicative total topic value (or ‘total project cost’);
- the topic area;
- the alignment with the strategic objectives of the IADP/ITD;
- the expected overall contribution: output, timeframe, major deliverables;
- the short-medium term objectives/milestones;
- the requirements related to the operational capacity (level of competences, level of technical capabilities, availability and capacities of specific resources, equipment, machineries track record etc);
- any specific legal, intellectual property and liability aspects in line with the provisions under the JU Model Grant Agreement for Members¹⁶ and with the IADP/ITD Consortium Agreement¹⁷;
- any specific confidentiality and competitive issues and any specific requirement (e.g Design Organism Agreement, Production Organism Agreement, etc)
- specific issues related to the Transversal Activities (TAs) where contributions stemming from the Topic will have relevance to one or more of the IADP/ITDs in addition to the TA itself.

¹⁵ The Clean Sky 2 “Joint Technical Programme” is the high-level programme as published by the CSJU following the independent evaluation performed on the work packages, technology streams and demonstrator projects proposed by the Leaders via the “Joint Technical Proposal.” *The Joint Technical Programme” will be implemented and updated across the duration of the Programme and of the CSJU in the form of a “Development Plan » to be formally approved by the CSJU which will define and update the full roadmap of the Programme.*

¹⁶ to be published by the CSJU at the launch of the call

¹⁷ To be published by the CSJU at the launch of the call or in due time before the start of the negotiation

Complementary Activities¹⁸

Applicants as Core Partners may also indicate in their proposal complementary activities and innovative solutions within the general topic area related to the Topic(s) for which they are applying and within the scope of the IADP/ITD where they can demonstrate that their capabilities and activities proposed:

- would represent an enhancement or improvement of the content of an IADP/ITD
- would lead to a demonstrable additional move beyond the state of the art in the Topic's general area.
- would be in line with the Programme's key goals and objectives

¹⁸ Applicable to calls for Core Partners. Complementary activities shall not be misunderstood with the additional activities defined in Article 4.2 of CSJU Regulation.

10.3. Accession of the Core Partner to the Grant Agreement for Member

The selected Core Partners will negotiate with the JU their accession to the Grant Agreement for Members (by signing an accession form) which will be already signed, where appropriate, between the JU and the Leaders of the relevant IADP/ITD/TA. The negotiation and accession stage will include the integration of the proposal, the work packages and technical activities of the Core Partner into the Annex I (Description of work and estimated budget) of the relevant IADP/ITD/TA Grant Agreement for Members. The Annex I will be subject to updates and revisions based on the multi-annual grant agreements framework in line with the multi-annual commitments and the programme management decision-making rules and governance framework under the CS2 Regulation.

The technical activities of the Core Partners will have to be aligned with the Programme objectives and strategic direction laid down in the Development Plan of the Clean Sky 2 Programme which will derive from the “Clean Sky 2 Technical Programme” and will be referred to in the Grant Agreement for Members.

Based on the above and in the light of the specific role of the Core Partner in the implementation of the Programme and JU governance structure, other activities in addition to the technical proposal of the topic may be performed by the Core Partners and be funded by the JU. In the course of the implementation and updates of the multi-annual Programme when the implementation of other areas of the Programme require the specific key capabilities of the Core Partners and its level of technical involvement in the implementation of the ITD/IADP/TA objectives.

The JU will define on the one hand, when the capabilities required and other areas of activities to be performed in an IADP/ITD/TA may be covered/absorbed by the existing level of capabilities at IADP/ITD/TA Members level, subject to a technical assessment of the JU and based on the Members multi-annual grant management process, and on the other hand when the capabilities required necessitate a call to be launched by the JU.

10.4. First Call for Core Partners JTI-CS2-2014-CPW01

The first call for Core Partners will be launched on the 9th of July 2014.

The following topics are opened in this Call for Core Partners (JTI-CS2-2014-CPW01). Detailed descriptions of the topics are provided in ***Annex I - 1st Call for Core-Partners: List and Full Description of Strategic Topics***.

Identification	Title	Short Description	Value (Funding in M€)
JTI-CS2-2014-CPW01-LPA			
JTI-CS2-2014-CPW01-LPA-01-01	Advanced Engine and Aircraft Configurations Strategic complementary research to prepare, develop and conduct large scale demonstration	Aerodynamic design and characterisation of advanced powerplant system (CROR, Turbofan for short- to mid-haul aircraft) integrated to the airframe based on CFRP structural components. Conceptual and detailed design and analysis of advanced powerplant solutions (UHBR, long-haul aircraft). Conceptual design of advanced powerplant solutions (hybrid energy powerplant systems). Definition and design of radical aircraft concepts.	15
JTI-CS2-2014-CPW01-LPA-01-02	Integrated Flow Control Applied to large Civil Aircraft	Hybrid Laminar Flow Control Large Scale Demonstration. Aerodynamic design of a fin equipped with HLFC technology. Support to definition of route towards certification. Analysis of achieved long-term flight-test data and assessment of net benefit of the HLFC technology.	4
JTI-CS2-2014-CPW01-LPA-01-03	Advanced HLFC fin design work: Structural design and manufacturing of operational HLFC fin	Hybrid Laminar Flow Control Large Scale Demonstration. Structure design of a fin equipped with HLFC technology. Development of all necessary tests, reports, means of compliance to accomplish an HLFC fin airworthy and mature for long term testing in operational flight. Development of the complete manufacturing process suitable for pre-serial production of the HLFC fin.	5

Identification	Title	Short Description	Value (Funding in M€)
JTI-CS2-2014-CPW01-LPA-01-04	Specific Design and Manufacturing of fuselage rear end and engine supports	Design, manufacturing, testing and complementary simulation of components for the rear mounted advanced propulsion system (CROR engine). Design and manufacturing of components for flight demonstration of the integrated CROR engine. Design, manufacturing, testing and simulation of components for the alternative advanced powerplant system (UHBR for short to mid-haul aircraft).	7,5
JTI-CS2-2014-CPW01-LPA-01-05	PoWer Turbine of the flight demonstrator CROR engine	Rotating Frames of the flight demonstrator Contra Rotating Open Rotor Engine Design adaptation or re-design of the Forward and Aft Rotating Frame (RF) for the Flight Test Demonstrator (FTD) CROR Engine; Manufacturing, Assembly/instrumentation of these Forward and Aft RF demo modules, tests to check the ability to fly, for example material or process tests on samples and Forward and Aft RF Modules for Scale 1 Component Tests	5
JTI-CS2-2014-CPW01-LPA-01-06	Rotating Frames of the flight demonstrator CROR engine	Power Turbine of the flight demonstrator Contra Rotating Open Rotor engine Design adaptation or re-design of the Power Turbine (PWT) for the Flight Test Demonstrator FTD CROR Engine Manufacturing, Assembly/instrumentation of this PWT module, tests to check the ability to fly, for example material or process tests on samples; Design , Manufacturing , Assembly/instrumentation and aero cold Test of a typical “ product” PWT module , tests to check the ability to fly, for example material or process tests on samples and Forward and Aft RF	5

Identification	Title	Short Description	Value (Funding in M€)
		Modules for Scale 1 Component Tests	
JTI-CS2-CPW01-LPA-02-01	Airframe Cabin and Cargo and System integration Architecture	Definition of functional & operational requirements of a next generation integrated Airframe-Cabin-Cargo-System architecture based on state-of-the-art requirements as starting point. Development of innovative overall fuselage airframe architecture with new integration approaches. Proposal of new material options for fuselage the structure, including integrated multi-functionalities. For the integrated approach, the concepts for advanced manufacturing shall focus to optimize production rates, manufacturing cost, installation efforts and the weight of the resulting integrated components and structures. Development of a Verification & Validation plan and close-to-reality testing for the final concept.	5
JTI-CS2-CPW01-LPA-02-02	Cabin & Cargo Functional System and Operations	Design, development and manufacturing of a linearly moveable and fully integrated Passenger Service Unit (PSU), development of the associated electronic equipment. Research and development for a decentralized power supply system based on the fuel cell technology with focus for an autonomous galley. Research, development and demonstration of an On-board Inert Gas Generation System (OBIGGS) able to perpetuate nitrogen enriched air as part of a halon-free, environmentally friendly cargo fire suppression system.	6,5

Identification	Title	Short Description	Value (Funding in M€)
JTI-CS2-CPW01-REG			
JTI-CS2-2014-CPW01-REG-01-01	Development of advanced systems technologies and hardware/software for the Flight Simulator and Iron Bird ground demonstrators for regional aircraft	This Strategic Topic is addressed to the development of: - innovative Systems technologies, in particular concerning Electrical Landing Gear and Flight Control System Topics, as well as Hardware/Software to build up an innovative Ground Demonstrator - named “Iron Bird”- that integrates the following systems: Flight Control, Electrical and Landing Gear. - software of advanced avionic functions to be integrated in a Regional Flight Simulator as well as realistic simulation models to improve the representativeness of such Simulator in order to support the validation of advanced avionics technologies for regional aircraft	5

Identification	Title	Short Description	Value (Funding in M€)
JTI-CS2-2014-CPW01-REG-01-02	Advanced wing for regional A/C - Technologies Development, Design and Manufacturing for FTB#1	This strategic topic is addressed to the development and maturation of: - innovative wing structure technologies including the verification and validation of a new methodologies for the life cycle design at Aircraft level taking advantages from simulation of allowable, manufacturing processes, operative behaviour and load structure interaction; the methodology is proposed and developed in the frame of the regional aircraft; the life cycle methodology is applied to the automated manufacturing and testing of the relevant advanced composite components considering certification requirements and effect of defect issues; - Air Vehicle technologies related to an innovative adaptive wing for future regional aircraft; to perform Verifications and Validation of these technologies, through Wind Tunnel test, and building full scale mechanical and structural concepts demonstrators for the developed devices concepts. From these technological development levels, innovative items shall be designed, manufactured and qualified for integration in the outboard wing section of the Flying Test Bed#1 for the final demonstration of TRL6.	6

Identification	Title	Short Description	Value (Funding in M€)
JTI-CS2-2014-CPW01-REG-02-01	Flight Physics and wing integration in FTB2	The activities of the core partner should be oriented to two different areas: • On one side the analysis in terms of loads, aerolastics and aerodynamics of the different concepts to be investigated in the frame of the FTB#2 wing, with the possibility to develop new tools to perform this analysis. • In addition, the integration of the different wing parts into the demonstrator wing once the selected concepts are developed through the Airframe ITD.	7
JTI-CS2-CPW01-FRC			
JTI-CS2-2014-CPW01-FRC-02-01	LifeRCraft airframe - Central and front fuselage sections - Design, Optimization, Manufacturing, V&V including airworthiness substantiation	Fuselage to be integrated with tail unit realised as part of AIR-ITD Topic #3 (WP B4.1-2) and with wing realized in AIR-ITD Topic #5 (WP B1.1-2). The optimized main airframe supports the wing, the main gearboxes, and the engines. It includes the cabin, the cockpit and integrates the main system of the aircraft. The activities cover the structural design according to Airbus Helicopters specification and architecture, the stress analysis, the manufacturing of the demonstrator airframe.	7,5

Identification	Title	Short Description	Value (Funding in M€)
JTI-CS2-2014-CPW01-FRC-02-02	LifeRCraft drive system- Main Gear Box input modules and equipped Propeller Gear Boxes - Design, Optimization, Manufacturing, V&V including airworthiness substantiation	Two propeller gearboxes (LH & RH) and specific MGB modules have to be developed for the compound rotorcraft demonstrator. The activities cover the design according to Airbus Helicopters specification and architecture, the stress analysis, the manufacturing of the gearboxes for ground tests and flight tests, and the analysis of the tests results.	6,5

Identification	Title	Short Description	Value (Funding in M€)
JTI-CS2-2014-CPW01-AIR			
JTI-CS2-2014-CPW01-AIR-01-01	New Innovative Aircraft Configurations and Related Issues	A-1 - Contribution of core partner to engine relevant integration studies, engine concepts analysis and engine performance assessment. Participation to the aircraft manufacturer architectural works: - Design preliminary concept and identify the main configuration parameters for MDO detail design - Design of new structural concepts (wing and fuselage) and assessment of the weight and the aerodynamic impacts - Detail design with high fidelity MDO approaches to identify optimal aircraft configurations accounting for aerodynamics, aeroelasticity, and structure. A-2 - Core-Partners from aero-structure industry will contribute for part design optimization & manufacturing especially at level of technologies for laminar surfaces. Applications will cover wing surfaces as well as nacelle external surfaces. A-4.2 - Development of methodology and system for the load, vibration and flutter active control, ground test and in flight tests and validation. Definition of an approach to certification. B-1.1 - Aerodynamic design of compound rotorcraft wing and interaction with propellers, including effect on noise emission B-4.1- Aerodynamic design of compound rotorcraft tail surfaces	16,5

Identification	Title	Short Description	Value (Funding in M€)
JTI-CS2-2014-CPW01-AIR-01-02	e-WIPS integration on novel control surface	This strategic topic addresses all the aspects of leading edge slat ice protection system technology, design and certification. For the N+2 generation, this strategic topic will continue the exploration of de-icing schemes which currently present significant technical challenges starting with the ability to create accurate computer models of their operation. The goal would be to develop completely the processes and tools needed to optimise the design of such systems. For the N+3 generation entering service in the 2030s, the strategic topic will lay the foundation of radically new approaches to ice protection, offering opportunities to study technology with lower maturity.	5
JTI-CS2-2014-CPW01-AIR-02-01	New wing and aircraft systems design and integration for Turboprop regional aircraft	Design, manufacturing and qualification for flight adapted in particular for the specific requirements of a new wing for an aircraft of the size of the regional turboprop and integration of equipment and systems based on novel technologies or using novel integration ways oriented to the more electrical high lift wing configuration aircraft. Special emphasis is put on structure embedded systems. In particular: specific and adapted new flight controls system for morphing wings including specific functions for load alleviation and high lift design characteristics with EMAs supplied at 270 VDC. New conformal, aerodynamically and structurally integrated SATCOM antenna research, new design landing gear electrical systems with health	5

Identification	Title	Short Description	Value (Funding in M€)
		monitoring and semi active shock absorption based in magneto-rheological fluids and new technologies ice protection systems based on two-phase heat transfer devices and on electrical induction on CFRP laminate surfaces.	
JTI-CS2-2014-CPW01-AIR-02-02	Wing and Tail Unit Components Multifunctional Design and Manufacturing (including Out of Autoclave composite)	Design and manufacture aeronautical components for Clean Sky 2 demonstrators: Regional Aircraft FTB2 (wing components) and LifeRCraft (tail unit). These components will include the state of the art in composite manufacturing (i.e. out of autoclave processes), innovative materials (i.e. thermoplastics) and adaption of structural architectures to host highly integrated systems, including criteria such as Eco-Design, Low Cost, High Quality and Low Weight objectives and requirements. (66% wing, 33% tail)	7,5

Identification	Title	Short Description	Value (Funding in M€)
JTI-CS2-2014-CPW01-AIR-02-03	Advanced technologies for more affordable composite fuselage	This Strategic Topic is addressed to the improvement of advanced technologies and methodologies coming from the Clean Sky - GRA ITD, FP7 MAAXIMUS, FP7 SARISTU with the aim to make them ready for the industrialization phase of a new regional aircraft fuselage. All proposed methodologies and technologies shall be validated by the building block approach, from the coupon level up to fuselage sub-component level (real scale flat and curved panels) through element level (details representative of skin/stringers, fittings, aft. pressure bulkhead, window frames, floor structure). The main expected outcome of this Strategic Topic shall consist of matured methodologies and technologies to be integrated in the full scale fuselage demonstrator within the WP 3.2 of Regional Aircraft IADP. The activities to be performed by the Core Partner are in the following 2 linked areas: 1) development of advanced methodologies and technologies for maintenance, repair, Non Destructive Inspection and Structural Health Monitoring; 2) fuselage components design, manufacturing and testing for verification and validation of new methodologies and technologies.	6,5

Identification	Title	Short Description	Value (Funding in M€)
JTI-CS2-2014-CPW01-AIR-02-04	Design and manufacturing of an advanced wing structure for rotorcraft additional lift	Design and manufacturing of an advanced wing structure for rotorcraft additional lift – Each half-wing insures a significant part of the rotorcraft lift and support a Propeller Gearbox, It includes a flap and a drive shaft is installed in the wing box. The activities cover the structural design according to Airbus Helicopters specification (including aerodynamic surface), the stress analysis, the manufacturing and the tests before first flight.	5,5
JTI-CS2-2014-CPW01-ENG			
JTI-CS2-2014-CPW01-ENG-01-01	Low Pressure Turbine Rear Frame (LP TRF) and Low Pressure Spool Shaft (LPS) for Ultra High Propulsive Efficiency (UHPE) Demonstrator for short / Medium Range Aircraft (WP2)	This topic includes design, manufacturing, instrumentation of the Low Pressure Turbine Rear Frame (TRF) and Low Pressure Spool (LPS) Shaft for UHPE GTD and test support for UHPE GTD. Innovation is required to develop a structural light weight Turbine Rear Frame (TRF) component.	5
JTI-CS2-2014-CPW01-ENG-01-02	Power GearBox (PGB) for Ultra High Propulsive Efficiency (UHPE) Demonstrator for Short/Medium Range Aircraft	This topic includes design, manufacturing, instrumentation and rig test of the alternative Power GearBox Module (PGB) for UHPE Ground Test Demo (GTD). Innovation is required for this high power high density PGB in order to get a significant advantage versus competition in terms of weight.	5

Identification	Title	Short Description	Value (Funding in M€)
JTI-CS2-2014-CPW01-ENG-01-03	Business Aviation / Short Regional TP demonstrator Front Power Plant Module	This call for Core Partner is dedicated to the Front Power Plant Module (FPPM). The core partner will be responsible for the design, development and component testing of the following subsystems: • Power & accessory gear box • Propeller and associated control system	6,5
JTI-CS2-2014-CPW01-ENG-02-01	Aerodynamic Design and Testing of advanced Geared Fan Engine Modules	The core partner for this proposal shall participate in WP4.1 & WP4.2 and shall be responsible for testing of the compressor rig in WP4.6. Testing of Rigs and Engine Demonstrator (JTP Chap 10.7.4 f). WP4.1 and WP4.2 include technology development as well as the development of test hardware for the compression system required for technology validation. WP4.6 consists of the technology development, development and provision of test enabling hardware, test execution and test evaluation for the compression system.	6
JTI-CS2-2014-CPW01-ENG-02-02	LPC, ICD and TEC development for next generation geared fan engines	The core partner for this proposal shall be responsible for the WP4.1. Compressor Intermediate Casing IMC (JTP Chap 10.7.4 a) and WP4.5. Turbine Exit Casing and Exhaust System (JTP Chap 10.7.4 e). WP4.1 includes technology development as well as the development and the provision of test hardware for the IMC and the rear part of the LP compressor required for technology validation. WP4.5 consists of the technology development, development and provision of test hardware for the Turbine Exit Casing and Exhaust System.	7

Identification	Title	Short Description	Value (Funding in M€)
JTI-CS2-2014-CPW01-ENG-03-01	VHBR Engine - IP Turbine Technology	The development and demonstration of various technologies required to deliver a High-Speed Low Pressure Turbine module for very high bypass ratio engine application (Aerodynamic, Aeromechanical, Material, Manufacturing and Methods) maximising turbine efficiency within a compact structure in order to maximize and validate overall performance, structural integrity, reduced weight, cost and noise benefits. Includes the design, development, build and test of modules required to demonstrate these technologies at a scale suitable for large engines in whole engine ground and flight testing.	20
JTI-CS2-2014-CPW01-ENG-03-02	VHBR Engine Structural Technology	The development and demonstration of various technologies required to deliver complex structural systems for very high bypass ratio engine application in order to maximize and validate overall performance, structural integrity, reduced weight, cost and noise benefits. Includes the design, development, build and test of subsystems required to demonstrate these technologies at a scale suitable for large engines in whole engine ground and flight testing.	5
JTI-CS2-2014-CPW01-ENG-04-01	More advanced and efficient small turbine engines for SAT market	Core-Partners from turbine engine industry will contribute for technologies developments and demonstration for engine components (High performance gas generator, Enhanced power turbine, Reduction gearbox and low noise propellers with integrated control system)	10

Identification	Title	Short Description	Value (Funding in M€)
JTI-CS2-2014-CPW01-SYS			
JTI-CS2-2014-CPW01-SYS-02-01	Power Electronics and Electrical Drives	Development of low TRL level technology bricks for power electronics component. New concept of embedded electronics and miniaturisation at system level. Reliability and aging studies. Network and equipment topologies trade-off studies and benchmarking.	5
JTI-CS2-2014-CPW01-SYS-03-01	Model, tools, simulation and integration	Modelling at aircraft level and measurement of new systems impact on overall architecture. Trade-off studies on breakthrough technologies. Development of simulation libraries and models to be customized by demonstrators designers. Core modelling environment with modular layers for customisation to specific aircraft platform and targeted technical area.	5

Note: The above funding values correspond to the average funding calculated by the JU based on the experience in the Clean Sky programme. The final funding value per topic will entirely depend on the cost structure of the winning entity, the funding rate, and the scope of work proposed in their application.

10.5. General outline for the Call for Core Partners JTI-CS2-2014-CPW01

Publication date: 09 July 2014

Deadline for submission (call closure date): Mid October

Overall indicative funding value: 205.5 million EUR

Eligibility and admissibility conditions: The conditions are described in parts B and C of the **General Annexes of the Work Plan**.

Evaluation criteria, scoring and threshold: The criteria, scoring and threshold are described in part F of the **General Annexes of the Work Plan**.

Evaluation procedure: The procedure for setting a priority order for applications with the same score is given in part F of the **General Annexes to the Work Plan**.

The full evaluation procedure is described in the **Rules for submission, evaluation, selection, award and review procedures for Calls for Core Partners** as published on the JU website and on the Participant Portal.

ITD/IADP Consortium agreement: Core Partners will be required to accede to the applicable ITD/IADP consortium agreement prior to the signature of grant agreement for members.

10.6. Second Call for Core Partners JTI-CS2-2014-CPW02

The second Call for Core Partners is foreseen to be launched in the first quarter of 2015. The related list of topics for this second call for Core-Partners is further presented below.

- **List of topics for Second Call for Core-Partners (2015 - Indicative)**

ITD/IADP/TA	Topic #	Title	Work Packages	Start Date of activities	Duration (number Years)	Value (Funding in M€)	Strategic topic leader
LPA IADP PL1	1	Electric machines and Component Integration applied on Radical AC Configurations	WP1.6	2015	6	5	Airbus
LPA IADP PL1	2	Advanced Engine and Aircraft Configurations - Package 2 including preparation, installation and demonstration of new engines	WP1.1 WP1.2 WP1.6	2015	8	6,8	Airbus & RR Uk
LPA IADP PL2	3	Airframe Components		1/nov/15	9	5	Airbus
LPA IADP PL2	4	Cabin & Cargo Components		1/nov/15	9	5	Airbus
LPA IADP PL3	5	Next generation cockpit functions, avionics: Work package and tasks related to the development of avionics technologies (Communication ,Navigation and surveillance - CNS)		Q3 2015	9	17	Airbus Dassault
LPA IADP PL3	6	Reduced cockpit workload: The objective of this call is to design and Develop technologies to improve Situation Awareness and reduce pilot workload keeping flight safety level and mission effectiveness. These technologies are aimed to simplifying the way of how flight crew interacts in the cockpit taking into account Human Factors aspects		Q3 2015	9	4,5	CASA
LPA IADP PL3	7	Next generation aircraft systems, cockpit systems and avionics, Work package and tasks related to the development of aircraft systems		Q3 2015	9	6	Airbus Dassault
LPA IADP	7					49,3	

ITD/IADP/TA	Topic #	Title	Work Packages	Start Date of activities	Duration (number Years)	Value (Funding in M€)	Strategic topic leader
R-IADP	1	Technological contributions to conceptual design of innovative regional aircraft configurations featuring advanced integration of powerplant	WP 1.1	1/06/2015	7	3,2	ALENIA
R-IADP	2	Demonstration Aircraft		1/01/2016	7	5	ALENIA
R-IADP	3	D&M of items for innovative fuselage/cabin demonstrator		1/01/2016	7	5,8	ALENIA
R-IADP	3					14	
FRC IADP	1	Design, manufacturing and testing of components for flight control system	FRC-TR WP6 T6.2	2015	6	10	AGUSTAW ESTLAND
FRC IADP	2	Design, manufacturing and testing of engine nacelle	FRC-TR WP5 T5.1	2015	6	5	AGUSTAW ESTLAND
FRC IADP	3	Design, manufacturing and testing of wing system components	FRC-TR WP4 T4.4	2015	6	7	AGUSTAW ESTLAND
FRC IADP	3					22	
AIRFRAME	1	Advanced composite cockpit and system installation		1/01/2016	5-7 years	4	EADS-CASA
AIRFRAME	2	Second run on the AIRFRAME topics, as a foreseen completion from first batch selection		1/01/2016	7	10	ALL
AIRFRAME/SAT	3	System integration – Fly-by-Wire		1/01/2016	7	5,5	PIAGGIO
AIRFRAME TS B-4, TB-4.2	4	Design, manufacturing and testing of fuselage structure		1/01/2016	6	13,5	AW
AIRFRAME	5	Innovation trailing edge multifunction control surfaces		1/01/2016	8	8	Dassault
AIRFRAME/SAT	6	Automated assembling		1/01/2016	7	4,5	EVEKTOR

ITD/IADP/TA	Topic #	Title	Work Packages	Start Date of activities	Duration (number Years)	Value (Funding in M€)	Strategic topic leader
T				6			
AIRFRAME/SAT		Optimized Composite Structures					PIAGGIO + EVEKTOR
AIRFRAME		Advanced Airframe Structure					DASSAULT & AIRBUS
AIRFRAME		Eco-Design for HPE Airframe (EDHA)					DASSAULT, AIRBUS, FhG
AIRFRAME		Cabin systems and Ergonomics, comfort & human perception improvements					ALENIA, DASSAULT, AIRBUS
AIRFRAME	10					76,5	
Engine	1	For UHPE demo (WP2) and to be confirmed: Several topics among Components of Low Pressure Turbine, Components of Controls & Systems, Components of Static Cold Structures		Q4 2015	6	9	Snecma
Engine	2	For UHPE demo WP2: Rotor Shaft and Bearings		Q4 2015			
LPA (SoW in Engine)	3	Tasks linked to Rotating Frames, PowerGearbox and Power Turbine (from SAGE 2)		Q4 2015	5	0	Snecma
ENGINES	3					9	

ITD/IADP/TA	Topic #	Title	Work Packages	Start Date of activities	Duration (number Years)	Value (Funding in M€)	Strategic topic leader
SYSTEMS	1	Multi-source weather data collection and fusion for better situation awareness		1/01/2016	4	5	TAES
SYSTEMS	2	Integrated Modular Avionics (IMC)		1/01/2016	4	7	TAES
SYSTEMS	3	Power Management Center for large aircraft : energy distribution		1/01/2016	6	5	LTS/TAES
SYSTEMS	4	Energy Storage		1/01/2016	4	5	All
SYSTEMS/SAT	5	Electric Systems		1/01/2016	7	8	SAT
SYSTEMS	5					42	
TOTAL Value funding						212,8	

Note: The above funding values correspond to the average funding calculated by the JU based on the experience in the Clean Sky programme. The final funding value per topic will entirely depend on the cost structure of the winning entity, the funding rate, and the scope of work proposed in their application.

10.7. Calls for Proposals (for Partners)

A first Call for Proposals (for Partners or ‘complementary grants’) is foreseen to be launched in the last quarter of 2014. The related list of topics for Partners is further presented below at point **10.11**.

The second and third Call for Proposals is foreseen to be launched in the 2nd and 4th quarters of 2015.

Partners

The partners will carry out objective driven research activities aiming at developing new knowledge, new technologies and solutions that will bring a contribution to one of the actions as defined in the Programme and developed in one of the IADP/ITDs/TAs.

The Partners' activities will be defined through topics proposed by the private Members of the JU and agreed by the JU, to complement their research activities where appropriate. The list of topics will be defined in the Work Plan with information such as the related IADP/ITD/ TA, the title of the topic, its duration and an estimate of the topic funding value. The nature and value of the Topics for Partners will be smaller in terms of magnitude and duration from the Topics for Core Partners.

The private Members of the JU will propose the scope, the objectives, the duration and the estimated budget associated to the Partners' activities that will be launched through Calls for Proposals (CfP) organised by the JU. The Partners' activities will consist of tasks limited in time and scope and they will be performed under the technical monitoring of the private Member acting in the call for proposal process as topic manager (the person representing the private Member in charge of the topic).

The Calls for Proposals will be subject to independent evaluation and will follow the H2020 rules on calls for proposals. Upon selection, the Partners will sign a Grant Agreement for Partners with the JU and its contribution will be made to either the final demonstrator or the set of activities which are performed by one or several CS2 Members in the frame of the Grant Agreement for Members. Partners will not become members of the JU and will not be expected to contribute to the running costs of the JU. Similarly, they will not participate in the steering committees of the IADP/ITDs.

More specifically, the Partners shall bring to the Programme the following:

- Short/medium-term commitment;
- A level and quality of resources consistent with the indicative total value of each Topic;
- Competences / capabilities necessary to carry out the activities aiming at developing new knowledge, new technologies and solutions contributing to the action. The activities will be defined from the beginning and might be of various type (study,

design, simulation, development, manufacturing, integration etc.) and closely related to the needs as per defined in every IADP/ITD;

The activities to be carried out in the context of the action performed by Partners may include the following:

- Research and technological development activities reflecting the core activities of the action, aimed at a significant advance beyond the established state-of-the-art, including scientific coordination;
and/or
- Demonstration activities, designed to prove the viability of new technologies that offer a potential economic advantage, but which cannot be commercialised directly (e.g testing of product-like prototypes),
and/or
- Any other activities such as:
 - ✓ monitoring activities, over and above the technical management of individual work packages, linking together all the action components and maintaining communications with both the JU and the Topic Manager ;
 - ✓ activities directly related to the action's objectives and likely to have a potential impact on the outcome of the action;
 - ✓ activities to disseminate and exploit the research results and to prepare for their take-up and use, including knowledge management and, activities directly related to the protection of foreground;
 - ✓ training of the researchers and key staff, including research managers and industrial executives (in particular for SMEs) and any potential users of the knowledge generated by the project. The training should aim to improve the professional development of the personnel concerned and be necessary to carry out the project work.

10.8. Definition of Topics

Partners will be selected on the basis of Topics which will be launched through the Calls for Proposals (CfP). Applicants interested in becoming Partners in the Clean Sky 2 Programme must submit proposals against one or more Topics. The proposals will be evaluated and the highest ranked proposals will be selected for funding by the JU.

The description of Topics will define the scope, goals, objectives and estimated duration of the activities to be performed by the successful applicant upon being selected a Partner.

The Topic description will be described in the call text.

Content of the Topic description:

- The name of the IADP/ITD to which the activity is linked;
- the proposed scope of work and tasks outputs as required within the IADP/ITD;
- an indicative total action value, no maximum value will be set;

- the alignment with strategic objectives of the IADP/ITD;
- the expected overall contribution: output, timeframe, deliverables and milestones;
- the competences required to run the action (expertise and skills, capabilities and track record) and to deal with risks associated to the activity (both at project and applicant level);
- the requirements related to the operational capacity (level of competences, level of technical capabilities, availability and capacities of specific resources, track record etc);
- any specific legal, intellectual property and liability aspects in line with the provisions of the JU model Grant Agreement for Partner and with the IADP/ITD Consortium Agreement or Implementation Agreement;
- Any specific confidentiality and competitive issues and any specific requirement (e.g holding a valid Design Organization Approval [DOA]; Agreement, Production Organization Approval [POA], etc.);

10.9. Technical implementation of the Partner's actions within the IADP/ITD - Access rights between private Members and Partners

The contribution of the Partner to the activities of the private Member and the objectives of the relevant IADP/ITD requires a close cooperation between the Topic Manager and the Partner selected by the JU to execute the work and implement the action under the Grant Agreement for Partner.

When assigned as Topic Manager in a Call for Proposals, the private Member shall monitor that the activities of the selected Partner are properly technically implemented and meet the objectives of the IADP/ITD and to provide a timely technical feedback/opinion to the JU which is in charge of the validation and approval of reports and deliverables.

In order to ensure an adequate framework for the cooperation between the private Member and the Partner, the latter is requested either to accede to the Consortium Agreement of the IADP/ITD, where applicable, or to negotiate and sign an implementation agreement with the private member which will define the framework of the cooperation.

In order to ensure the correct implementation of the action, a mutual access rights regime shall apply to the Topic Manager and the selected Partner. The access rights regime shall apply at action level. More specifically the Topic Manager and the selected Partner shall grant mutual access rights under the same conditions to the background for implementing their own tasks under the action and for exploiting their own results. Specific provisions will be laid down in the respective Model Grant Agreement for Members and Model Grant Agreement for Partners¹⁹.

¹⁹ Under the conditions set out in Article 25.2 and 25.3 of the H2020 model grant agreement

10.10. List of topics for Partners (first Call for Proposals, 2014) – Indicative

ITD/IADP/T A	Topic #	Title	Work Packages	Start Date of activities	Duration (number Years)	Value (Fund ing in M€)
LPA IADP PL2	1	Integration enablers. 3 topics		01.June 15	4	7
LPA IADP PL3	2	Activities related to maintenance planning and performance optimisation through fleet data management capabilities:* Collaborative environment incl. data mining, * Maintenance task planning taking into account flight schedules and available resources, Activities related to maintenance execution enhancement by remote support functionalities and integration of mobile tool solutions, Activities related to "conditions based maintenance" enabling capabilities and technologies such as Integrated Health Monitoring and Management (IHMM)		Q2 2015	4	7,5
LPA IADP PL3	3	Maintenance SHM		Q2 2015	4	2,4
LPA IADP PL3	4	Fuel leaks detectors for fuel leak detection and control		Q2 2015	2	0,095
LPA IADP	4					16,995
R-IADP	1	Future Regional Network Development: Airlines Fleet Requirements and Socio-Economic Impacts	WP1.1, WP1.2, WP2.2	1/09/2015	1,5	0,4
R-IADP	2	High/low voltage DC/DC "resonant cellular" converter with automatic inversion for innovative "smart-grid" based electrical network (as part of "Generalized" Energy Management concept)	WP2.3.4, WP3.3	1/09/2015	2	0,45

ITD/IADP/T A	Topic #	Title	Work Packages	Start Date of activities	Duration (number Years)	Value (Fund ing in M€)
R-IADP	3	Preliminary design of a regional TP wing including active control concepts	WP3.5	1/09/2015	1,5	0,25
R-IADP	3					1,1
FRC-2	FRC2 .1.1	Optimization and assessment of LifeRCraft airframe aerodynamic characteristics including propeller interaction based on CFD and experimental means	WP2.1.7	1/09/2015	1,5	1
FRC-2	FRC2 .2.1	LifeRCraft airframe weight reduction thru load and stress analysis and advanced structural optimisation techniques	WP2.2.6	1/10/2015	1,5	0,5
FRC-2	FRC2 .2.2	Adaptation of fast prototyping techniques to the LifeRCraft airframe components and specifications	WP2.2.7	1/09/2015	1	0,5
FRC-2	FRC2 .3.1	Landing system for LifeRCraft demonstrator - Design, manufacturing and substantiation for airworthiness	WP2.3.6	1/09/2015	2,5	2,2
FRC-2	FRC2 .5.1	LifeRCraft Propeller aeroacoustic design and tailoring and experimental validation.	WP2.5.8	1/09/2015	2	0,5
FRC-2	FRC2 .5.2	LifeRCraft propeller mechanical design, realization, and substantiation for airworthiness	WP2.5.9	1/09/2015	2	1,5
FRC-2	FRC2 .8.1	LifeRCraft electrical generation, storage and conversion - Design, realisation, test and delivery for demo (several topics, details TBD)	WP2.8.7	1/okt/15	2,5	0,8
FRC-2	FRC2 .8.2	LifeRCraft electrical storage - Design, realisation, test and delivery for demo	WP2.8.8	1/sep/15	2,5	0,8
FRC-2	FRC2 .8.3	LifeRCraft electrical converters- Design, realisation, test and delivery for demo	WP2.8.9	1/sep/15	2,5	0,4
FRC-2	FRC2 .12.1	Smart flight profile for LifeRCraft demonstrator fuel savings	WP2.12.2 .2	1/okt/15	3	0,8
FRC-2	FRC2 .12.2	Design of neighbour-friendly approach & departure trajectories suited for compound rotorcraft	WP2.12.3 .2	1/okt/15	3	0,3

ITD/IADP/T A	Topic #	Title	Work Packages	Start Date of activities	Duration (number Years)	Value (Fund ing in M€)
FRC-TR WP6 T6.1	1	Design, manufacturing and testing of components of EPGDS		2015	4	3,5
FRC IADP	12					12,8
AIRFRAME	1	Flaps actuation system for compound rotorcraft wing Actuation system including sensors and position control differentiated LH/RH sides and interfacing with FCS. Actuators may either or not be included in this WP (to be defined)	B-1.1-3	end 2015	3	0,5
AIRFRAME	2	Optimization of rotorless tail structural concepts & architecture Optimization of LifeRCraft tail structural concept and architecture, in support of industrial Core-Partner in charge of design and realisation	B-4.1-3	end 2015	2	0,5
AIRFRAME	3	WPB-4.3 Process development for composite frames manufacturing with high production rate and low cost To develop an advanced process for regional a/c composite fuselage frames manufacturing which allows a significant reduction of the overall production costs and timing. Suitable processes and materials shall be investigated and screened. An opportune Test Plan shall be defined to assess the mechanical characteristics of the material, the quality of the realized trials of manufacturing and the quality repeatability. Tests shall be performed according to the defined Test Plan following the building block approach at coupons, elements and sub-components level. Demonstrators realized with the identified and set up process will be finally provided.	B-4.3	1/09/2015	2	0,3

ITD/IADP/T A	Topic #	Title	Work Packages	Start Date of activities	Duration (number Years)	Value (Fund ing in M€)
AIRFRAME	4	WPB-4.4 Simulation technologies and Virtual design platform/procedures for human centered cabin design for regional a/c To develop virtual reality setups which shall be used to support the design and simulate an immersive verification cabin environment, allowing a step-by-step optimisation of the interiors design solution for cabin regional aircraft. The platform shall be able to manage large possibilities of cabin parameters variation (ergonomic, visibility, colours, lay out, lightening patterns, acoustics, temperature etc.); manikin adjustable “on demand” (tall, thin, big legs, etc.), prediction of inter-passengers acoustical parameters etc.	B-4.4	1/09/2015	2	0,4
AIRFRAME	5	WPB.4.4 Manufacturing Simulation / Process Control for cabin interiors green materials for the regional a/c To develop and qualify the use of green materials for cabin interiors application and also to define the “green” principles and procedures for manufacturing and process control. The target shall be to have for green product a quality repeatability results to assure a stable and efficient product with respect to weight/cost/performance requirements. Test at coupons, elements and sub-components level shall be performed as pilot lines for maturity demonstration gate to integrate new technology according to the test plan and procedures.	B-4.4	1/09/2015	2	0,5

ITD/IADP/T A	Topic #	Title	Work Packages	Start Date of activities	Duration (number Years)	Value (Fund ing in M€)
AIRFRAME	6	Nacelle integrated structures Development of technologies for highly integrated nacelles. Systems and equipment for the full scale demonstrator. Preparation activities for technologies validation through Icing Wind Tunnel Testing (IWT) and acoustic measurement facilities.	B-3.1	2015	6	3
AIRFRAME ITD	6					5,2
ENGINE	1	VHBR Engine - Control System Technology Package 1		Q3 2015	4	2
ENGINE	2	VHBR Engine - Engine Health Monitoring Technology Package 1		Q3 2015	4	2
LPA (SoW in Engine)	3	Tasks linked to Pitch Control Mechanism (from SAGE 2)		2015	6	0
ENGINE	4	Manufacturing Technologies and Demo HW		Q2 2015	5	2
ENGINE	5	Diesel Engine activities, including propeller, FADEC and aircraft for integration activities. This CfP will address (in cooperation with the leader) the following activities: • Material, design & manufacturing (cylinder & cylinder head) • Performance and operability: Turbocharger system, injection system, engine management. • Propeller • Alternative architectures (two stroke engines, hybrid engines) • On wing installation	SAT WP E.3 / ITD Engine WP 7: Light weight and fuel efficient compression ignition power unit	1/06/2015	3	4,9
ENGINES ITD	5					10,9

ITD/IADP/T A	Topic #	Title	Work Packages	Start Date of activities	Duration (number Years)	Value (Fund ing in M€)
SYSTEMS	1	Smart Integrated Wing: Bus architecture Benchmarking of new physical bus supports (optical fibre, wireless, data on power...) and development of a physical bus architecture accordingly for large scale wing systems demonstration. The bus architecture should be mounted on the Smart Integrated Wing, targeting TRL5 in 2018.	WP3.1	1/09/2015	3	0,5
SYSTEMS	2	Smart Integrated Wing: hydrostatic lubrication and sealing concepts As a first step in hydraulic network reduction, the electro-hydrostatic actuation systems are suffering from the fluid reduction. The leakage detection and prevention is more than ever critical and new lubrication and sealing concepts should be studied, in order to solve these issues.	WP3.2	1/09/2015	3	0,75
SYSTEMS	3	Nose Landing Gear: health monitoring technologies According to EHA Nose landing gear system health monitoring strategy, innovative measurement capabilities and sensors technologies should be studied and developed to match the needs of landing gear monitoring and preventive maintenance, such a hard landing and leakage detection.	WP4.2	1/09/2015	3	1,5

ITD/IADP/T A	Topic #	Title	Work Packages	Start Date of activities	Duration (number Years)	Value (Fund ing in M€)
SYSTEMS	4	Innovative Electrical Wing (WP3): Virtualisation & Technologies In order to support the demonstration “Innovative Electrical Wing” focusing on Flight Control Systems for Regional Aircraft applications, activities related on virtualisation/simulation in multi-physics domain are expected, as well as technological bricks such as power electronics, drives and mechanical parts	WP3	1/09/2015	4	0,6
SYSTEMS	5	Innovative Electrical Wing (WP3): V&V test bed (incl. HMI) In order to support the demonstration “Innovative Electrical Wing” focusing on Flight Control Systems for Regional Aircraft applications, the development of a Verification and Validation test bed, including its associated Human Machine Interface systems is required. It will be used to support the V&V phase of the hardware and software developed in the frame of the IEW project.	WP3	1/09/2015	3	0,75

ITD/IADP/T A	Topic #	Title	Work Packages	Start Date of activities	Duration (number Years)	Value (Fund ing in M€)
SYSTEMS	6	New IHS devices and approaches (could be several CfPs) The need for new IHS devices is driven by several concurring factors: - The availability of technological enablers (computing power, display surface, ...) - The maturation of new interface concepts in consumer electronics (tactile, haptic, signs, voice, ...) - The need for more crew awareness and the possibility/obligation to manage and integrate more data onboard (SESAR, NextGen, AOC, weather, ...) - The need for new workshares and crew organisation - Potential gains in weight/complexity Through several CfPs, work performed in current national or European projects will be integrated in the Cockpit demonstrators and the use cases, synergies, conflicts will be evaluated. In addition, new technologies will be called for.	WP1.2	1/09/2015	2	4
SYSTEMS	7	Energy storage for high voltage application Energy storage for high voltage application consists of evaluating the supercapacitor technology into taking account aircraft environmental requirements. The analysis will include a road map of the supercapacitor technology, a development of prototypes for a specific application and V&V phase.	WP5.1	1/09/2015	2	0,5

ITD/IADP/T A	Topic #	Title	Work Packages	Start Date of activities	Duration (number Years)	Value (Fund ing in M€)
SYSTEMS	8	Power component in harsh environment Electrical components need to meet harsher aircraft requirements; mechanical constraints combined with high temperature conditions weaken the die of the component. The targets are to develop robust package for harsh environment and to optimize electrical characteristic of component. The foreseen application is a rectifier bridge using high current diode,	WP5.1	1/09/2015	2	0,5
SYSTEMS	9	Electrical machine: Sensors Linear oil pressure sensor is required for oil cooled electrical generator health monitoring; pressure value associated with temperature and speed information can permit a preventive maintenance of the oil circuit equipment. The high accuracy requirement must be held in a large temperature range and must stand a very harsh vibratory and electromagnetic environment.	WP5.1	1/09/2015	2	0,8
SYSTEMS	10	Electrical Machine: Test Bench Test bench for simulating large bandwidth torsional vibration: all the drive shafts between the engine and the rotor of a starter/generator are concerned by torsional vibration due to load variation or resonance phenomenon. Those vibrations can lead to an early ageing or the destruction of mechanical pieces. The tests bench must be able to drive Speed/Torque with a large dynamic bandwidth.	WP5.1	1/09/2015	5	2

ITD/IADP/T A	Topic #	Title	Work Packages	Start Date of activities	Duration (number Years)	Value (Fund ing in M€)
SYSTEMS	11	Development and manufacturing of an Electro-thermal Ice Protection Assembly In order to support the wing protection demonstration, this CFP aim to develop a relevant electrothermal wing ice protection system for Large aircraft based on preliminary work performed in JTI Clean-Sky with focus on improvement of system/structure integration, the maintainability and reparability.	WP6.2	1/09/2015	2	3
SYSTEMS	12	Development of MODELICA libraries for VCS modelling Development of a Modelica models for aircraft air conditioning and thermal management architecture and components. The models will be optimized for unsteady state modelling (for transient modes).	WP6.1	1/09/2015		0,5
SYSTEMS	13	Main Landing Gears (WP4): technology bricks for Green Taxiing applications The Green Taxiing concept to move the aircraft on ground while the main engines are shut down will be considered as new equipment for the next generations of commercial aircrafts if some key enablers are available, such as compact EMA for harsh environment and enhanced energy recovery systems. Integration of the system in the wheels of the main landing gears where the braking and cooling systems are already present is challenging and implies availability of new components able to meet the requirements (performances, reliability, safety...).	WP 4.1	1/09/2015	5	2,5
SYSTEMS ITD	13					17,9

10.11. Submission of proposals from applicants

The process related to the submission of proposals as Core Partner is explained in the JU *“Rules for the submission of proposals, evaluation, selection, award and review procedure of Core Partners”* available on the CSJU website: <http://www.cleansky.eu/>

The Calls for Proposals (for Partners) process will follow the *H2020 rules on calls for proposals*.

On a practical level, both the Calls for proposals and Calls for Core Partners will make use of the European Commissions’ participant portal:

<http://ec.europa.eu/research/participants/portal/desktop/en/home.html>

11. OBJECTIVES AND INDICATORS

The overall objectives for the period 2014-2015 are:

- To staff the JU team up to the agreed level of 42;
- To elaborate the technical content of the overall programme and ensure this is adequately incorporated in the *CS2 Joint Technical Programme* and the Grant Agreements: (including the (re-)evaluation of elements of the Programme where needed);
- To conduct Launch Reviews for 100% of technical activity commencing in the 2014-15 period, enabling the JU to adequately test the level of definition, of preparation and resourcing geared towards each major activity. The state of play of the relevant CS projects will be a key consideration in these Launch Reviews, in order to ensure an effective and appropriate transition from CS to CS2;
- To define the requirements for the Demonstration Programme – as this is a new programme with new objectives, the requirements of the demonstrators which are targeted need to be worked out; within each area, this step is essential to help to set the basis for the following years' work plans to be drawn up;
- To refine the Technology Roadmaps as elaborated in each of the sections of the CS2 Joint Technical Proposal related to the IADPs, ITDs and TAs, including where necessary a review and revision of content and priorities (for instance as a consequence of the review of former “Level 2” projects);
- To propose solutions for leveraging Clean Sky 2 funding with Structural Funds;
- To define and implement an effective and efficient management and governance set of rules through the Clean Sky 2 Management Manual;
- To define an appropriate model for each transverse area that allows for the transversal coordination to be executed and technical synergies to be extracted;
- To launch and select the first and second wave of Core-Partners;
- To widely disseminate the information about the first three Calls for Proposals (i.e. call for partners), in order to reach a participation from SMEs higher than 35%. To proceed with the selection of these calls;
- To define the reference framework for the TE (including performance levels of reference aircraft against which the progress in CS2 will be monitored); and to elaborate the assessment criteria and evaluation schedule for the TE for each technical area. To launch the CS2 TE and complete the selection of its key participants;
- To ensure a time-to-grant lower than 8 months from the call for proposal closure;
- To train the JU financial staff on the specific eligibility rules for CS2 Programme and organise information sessions on the subject with the members and core partners.
- To execute at least 90% of the budget and of the relevant milestones and deliverables;
- To contribute to the development of the Terms of Reference required for adequate reporting of the private members contributions to the JU.

11.1. Clean Sky 2 Demonstrators and Technology streams

IADP / ITD	Technology Areas	Demonstrator / Technology Stream
Large Passenger Aircraft	Advanced Engine Design & Integration for Large Passenger Aircraft	CROR demo engine flight test demo
		Advanced engine integration driven fuselage ground demonstrator
		Validation of dynamically scaled integrated flight testing
Large Passenger Aircraft	Advanced Laminar Flow Rig Reduction for Large Passenger Aircraft	HLFC large-scale specimen demonstrator in flight operation
		High speed demonstrator with hybrid laminar flow control wing
Large Passenger Aircraft	Innovative Aircraft Configuration and Operation	Innovative Flight Operations Next generation cockpit and MTM functionalities
		Demonstration of advanced short-medium range aircraft configuration
Large Passenger Aircraft	Innovative Cabin & Cargo Systems and Fuselage Structure Integration for Large Passenger Aircraft	Full-scale advanced fully integrated fuselage cabin & cargo demonstrator
		Next generation lower centre-fuselage structural demonstrator
		Next generation large module fuselage structural demonstrator with fully integrated next generation cabin & cargo concepts and systems
Large Passenger Aircraft	Next Generation Cockpit & Avionic Concepts and Functions for Large Passenger Aircraft	Integrated systems and avionics demonstration Full 4D - flight capability; fully parameterized green trajectory capability
		Next Generation Cockpit ground demonstrator Development and validation suite for: - New MMI functions - Advanced IMA's - Networked data link and functions Fully integrated next generation avionics simulation & test lab
		Flight demonstration Next Generation Cockpit & flight operation features Coordinated with Systems and Equipment ITD

IADP / ITD	Technology Areas	Demonstrator / Technology Stream
		"Pilot case" demonstration in flight Qualification and validation of next generation cockpit features sensible to a highly realistic environment Maintenance service operations enhancement demonstrator Demonstration of the technical and economic maturity and performance of a value and service oriented architecture and its enablers
Regional Aircraft	Highly Efficient Low Noise Wing Design for Regional Aircraft	Air Vehicle Technologies – Flying Test Bed#1 (FTB1) Low noise and high efficient HLD, NLF, Active LC&A, Innovative wing structure and systems
Regional Aircraft	Innovative Passenger Cabin Design & Manufacturing for Regional Aircraft	Full scale innovative Fuselage and passenger Cabin
Regional Aircraft	Advanced for Regional Aircraft: 1. Power Plant 2. Flight Simulator 3. Iron Bird	WTT for Configuration of Next Generation Hi-Efficient Regional A/C with Innovative configuration, advanced powerplant integration, efficient technologies insertion at A/C level Flight Simulator with New cockpit interaction concepts, advanced avionics functionalities (including pilot workload reduction) , MTM (green functions in a global environment) Iron Bird with Innovative systems integration, Next generation flight control systems (H/W and pilot in the loop)
Regional Aircraft	Innovative Future Turboprop Technologies for Regional Aircraft	High Lift Advanced Turboprop – Flying Test Bed#2 (FTB2)
Fast Rotorcraft: Tiltrotor	Advanced Tilt Rotor Structural & Aero-acoustic Design	D1: Mock-up of major airframe sections and rotor D2: Tie-down helicopter (TDH) D3: NextGenCTR flight demonstrator (ground & flight) D4: Prop-rotor components and assembly
Fast Rotorcraft: Tiltrotor	Advanced Tilt Rotor Aerodynamics and Flight	D6: NextGenCTR's fuselage assembly D7: NextGenCTR's wing assembly

IADP / ITD	Technology Areas	Demonstrator / Technology Stream
	Physics Design	D8: Engine-airframe physical integration D9: Fuel system components
Fast Rotorcraft: Tiltrotor	Advanced Tilt Rotor Energy Management System Architectures	D5: NextGenCTR's drive system components and assembly
		D10: intelligent electrical power system and ancillary/ auxiliary components D11: Flight control & actuation systems and components
Fast Rotorcraft: Tiltrotor	Tiltrotor Flight Demonstrator	Tiltrotor Flight Demonstrator
Fast Rotorcraft: Compound R/C	Innovative Compound Rotorcraft Airframe Design	Airframe structure & landing system <i>NB: Wing and tail addressed in Airframe ITD dedicated WPs (1.8, 1.11)</i> To include: – advanced composite or hybrid metallic/composite structure using latest design and production techniques – Specific landing system architecture & kinematics
Fast Rotorcraft: Compound R/C	Innovative Compound Rotorcraft Power Plant Design	Lifting Rotor & Propellers Integrated design of hub cap, blades sleeves, pylon fairings, optimized for drag reduction; Rotor blade design for combined hover-high speed flight envelope and variable RPM; Propeller design optimized for best dual function trade-off (yaw control, propulsion);
		Drive train & Power Plant Engine installation optimized for power loss reduction, low weight, low aerodynamic drag, all weather operation; New mechanical architecture for high speed shafts, Main Gear Box input gears, lateral shafts, Propeller Gear boxes, optimized for high torque capability, long life, low weight. REACh-compliant materials and surface treatments.

IADP / ITD	Technology Areas	Demonstrator / Technology Stream
Fast Rotorcraft: Compound R/C	Innovative Compound Rotorcraft Avionics, Utilities & Flight Control Systems	On board energy, cabin & mission systems Implementation of innovative electrical generation & conversion, high voltage network, optimized for efficiency & low weight; advanced cabin insulation & ECS for acoustic and thermal comfort.
		Flight Control, Guidance & Navigation Systems Smart flight control exploiting additional control degrees of freedom for best vehicle aerodynamic efficiency and for noise impact reduction.
Fast Rotorcraft: Compound R/C	LifeRCraft Flight Demonstrator	LifeRCraft Flight Demonstrator Integration of all technologies on a unique large scale flight demonstrator, success & compliance with objectives validated through extensive range of ground & flight tests
Airframe	High Performance and Energy Efficiency	Innovative Aircraft Architecture Noise shielding, noise reduction, Overall Aircraft Design (OAD) optimisation, efficient air inlet, CROR integration, new certification process, advanced modeling
		Advanced Laminarity Laminar nacelle, flow control for engine pylons, NLF, advanced CFD, aerodynamic flow control, manufacturing and assembly technologies, accurate transition modelling, optimum shape design, HLF
		High Speed Airframe Composites (D&M), steering, wing / fuselage integration, Gust Load Alleviation, flutter control, innovative shape and structure for fuselage and cockpit, eco-efficient materials and processes
		Novel Control Gust Load Alleviation, flutter control, morphing, smart mechanism, mechanical structure, actuation, control algorithm

IADP / ITD	Technology Areas	Demonstrator / Technology Stream
		Novel Travel Experience Ergonomics, cabin noise reduction, seats & crash protection, eco-friendly materials, human centered design, light weight furniture, smart galley
Airframe	High Versatility and Cost Efficiency	Next Generation Optimized Wing Box Composite (D&M), out of autoclave process, modern thermoplastics, wing aero-shape optimisation, morphing, advanced coatings, flow and load control, low cost and high rate production
		Optimized High Lift Configurations Turboprop integration on high wing, optimised nacelle shape, high integration of Tprop nacelle (composite/metallic), high lift wing devices, active load protection
		Advanced Integrated Structures Highly integrated cockpit structure (composite metallic, multifunctional materials), all electrical wing, electrical anti-ice for nacelle, integration of systems in nacelle, materials and manufacturing process, affordable small aircraft manufacturing, small a/c systems integration
		Advanced Fuselage Rotor-less tail for fast r/c (CFD optimisation, flow control, structural design), pressurised fuselage for fast r/c, more affordable composite fuselage, affordable and low weight cabin
Engines	Innovative Open Rotor Engine Configurations	Open Rotor Flight Test Ground test and flight test of a Geared Open Rotor demonstrator: - Studies and design of engine and control system update and modifications for final flight test - Manufacturing, procurement and engine assembly for ground test checking before flight Following on flight test planned in LPA IADP and test results analysis

IADP / ITD	Technology Areas	Demonstrator / Technology Stream
Engines	Innovative High Bypass Ratio Engine Configurations I : UHPE Concept for Short/Medium Range aircraft (Safran)	UHPE demonstrator Design, development and ground tests of a propulsion system demonstrator for an Ultra High By-pass Ratio engine: validation of the low pressure modules and nacelle technology
Engines	Business Aviation/Short Range Regional Turboprop Demonstrator	Business aviation/short range regional Turboprop Demonstrator Design, development and ground testing of a new turboprop engine demonstrator for business aviation and short range regional application
Engines	Advanced Geared Engine Configuration	Advanced Geared Engine Configuration (HPC and LPT technology demonstration) Design, development and ground testing of an advanced geared engine demonstrator: improvement of the thermodynamic cycle efficiency and noise reduction
Engines	Innovative High Bypass Ratio Engine Configurations II: VHBR Middle of Market Turbofan Technology (Rolls-Royce)	VHBR Middle of Market Turbofan Technology Design, development and ground testing of a VHBR Middle of Market Turbofan
Engines	Innovative High Bypass Ratio Engine Configurations III: VHBR engine demonstrator for the large engine market (Rolls-Royce)	VHBR engine demonstrator for the large engine market Design, development and ground testing of a large VHBR engine demonstrator
Engines	Small Aircraft Engine Demonstrator	Small Aircraft Engine Demonstrators - reliable and more efficient operation of small turbine engines - light weight and fuel efficient diesel engines

IADP / ITD	Technology Areas	Demonstrator / Technology Stream
Systems	Integrated Cockpit Environment for New Functions & Operations	Extended Cockpit Demonstrations for: - Flight Management evolutions : green technologies, SESAR, NextGen, interactive FM - Advanced functions : communications, surveillance, systems management, mission management - Cockpit Display Systems: new cockpit, HMI, EVO, etc. - IMA platform and networks
Systems	Innovative and Integrated Electrical Wing Architecture and Components	Innovative Electrical Wing Demonstrator (including ice protection) for: - New actuation architectures and concepts for new wing concepts - High integration of actuators into wing structure and EWIS constraints - Inertial sensors, drive & control electronics - New sensors concepts - Health monitoring functions, DOP - WIPS concepts for new wing architectures - Shared Power electronics and electrical power management Optimization of ice protection technologies and control strategy

IADP / ITD	Technology Areas	Demonstrator / Technology Stream
Systems	Innovative Technologies and Optimized Architecture for Landing Gears	Advanced systems for nose and main landing gears applications for: - Wing Gear and Body Gear configurations - Health Monitoring - Optimized cooling technologies for brakes - Green taxiing - Full electrical landing gear system for NLG and MLG applications - EHA and EMA technologies - Electro-Hydraulic Power Packs - Remote Electronics, shared PE modules - Innovative Drive & Control Electronics

IADP / ITD	Technology Areas	Demonstrator / Technology Stream
Systems	High Power Electrical and Conversion Architectures	Non propulsive energy generation for: - AC and DC electrical power generation - AC and DC electrical power conversion - SG design for high availability of electrical network - Integrated motor technologies, with high speed rotation and high temperature material
		Equipment and Systems for new aircraft generations
Systems	Innovative Energy Management Systems Architectures	Innovative power distribution systems, (including power management) for: - Electrical Power Centre for Large Aircraft – load management and trans-ATA optimization - High integrated power center for bizjet aircraft (multi ATA load management, power distribution and motor control) - Smart grid, develop & integrate breakthrough components to create a decentralized smart grid, partly in non-pressurized zone. - Electrical Power Centre – load management optimization - Health Monitoring, DOP compliant
Systems	Innovative Technologies for Environmental Control System	Next Generation EECS, Thermal management and cabin comfort for: - New generation of EECS including a global trans ATA visionable to answer the needs for load management, Inerting systems, Thermal Management, Air quality & cabin comfort - Development / optimisation of Regional A/C EECS components for full scale performance demonstration - New generation of cooling systems for additional needs of cooling

IADP / ITD	Technology Areas	Demonstrator / Technology Stream
Systems	Advanced Demonstrations Platform Design & Integration	Demonstration Platform – PROVEN, GETI & COPPER Bird® - To mature technologies, concepts and architectures developed in <i>Clean Sky 2</i> or from other R&T programs and integrated in <i>Clean Sky 2</i> - For optimization and validation of the thermal and electrical management between the main electrical consumers
Systems	Small Air Transport (SAT) Innovative Systems Solutions	Small Air Transport (SAT) Activities - Efficient operation of small aircraft with affordable health monitoring systems - More electric/electronic technologies for small aircraft - Fly-by-wire architecture for small aircraft - Affordable SESAR operation, modern cockpit and avionic solutions for small a/c - Comfortable and safe cabin for small aircraft <i>Note: budget has been identified for specific SAT work inside Systems. However, synergies with main demonstrators and specific work still have to be worked upon</i>
Systems	ECO Design	ECO Design activities Refers to ECO Design chapter
Technology Evaluator (TE)	A systematic overall approach to the Technology Evaluation process and monitoring activity	- Progress Monitoring of <i>Clean Sky 2</i> achievements - Evaluation at Mission Level of particular ITD outputs - Impact Assessments at Airport and ATS Level

IADP / ITD	Technology Areas	Demonstrator / Technology Stream
Eco-Design Transverse Activity	An overall innovative approach and "agenda" for Eco-Design activity in the CS2 Programme	Eco-Design activities are embedded in all IADPs and ITDs. They are detailed in Chapter 13. Thus, a dedicated funding for Eco-Design is reserved inside each IADP's and ITD's funding. The co-ordination of all Eco-Design activities will be established in the Airframe ITD. The list of technology areas and "story boards" and demonstrators will be established during the 2014-15 period.
Small Air Transport (SAT) Transverse Activity	An overall innovative approach and "agenda" for Small Air Transport activity in the CS2 Programme	Small Air Transport (SAT) activities are part of Airframe, Engines (WP7) and Systems ITDs and are detailed in Chapter 14. The co-ordination of all SAT activities will be established in the Airframe ITD. The planned demonstrators are included in the above descriptions of the Airframe, Engines and Systems ITDs.
LEGEND		
IADP/ITD/TA	Technology Area	Demonstrator / Technology Stream <i>Text highlighted as indicated relates to demonstrators foreseen within the CS2 Programme for which an ex-ante Technical Evaluation by independent experts is still required. As such they are noted here as conditional - subject to a successful evaluation.</i>

11.2. Environmental forecast

The table below shows the environmental targets of the Clean Sky 2 Programme as defined in the Joint Technical Proposal.

	<i>Clean Sky 2 as proposed*</i>
CO ₂ and Fuel Burn	-20% to -30% (2025 / 2035)
NO _x	-20% to -40% (2025 / 2035)
Population exposed to noise / Noise footprint impact	Up to -75% (2035)

* Baseline for these figures is best available performance in 2014

These figures represent the additionality of CS2 versus the 2014 Horizon 2020 Start Date and allow the full completion of the original ACARE 2020 goals (with a modest delay)

11.3. Indicators for Clean Sky 2 Programme

The following table presents the list of indicators (Key performance Indicators) set up for the CS2 programme.

Indicator ID	Indicator short name	Description of indicator	Target set
Ind 1.4 C	SME share in CfPs - numbers	number of SME participation in CfP versus total number of applicants	>40%
Ind 2.5.1 B	Core Partner Topics success rate	percentage of topics resulting in signature of the GAM	>90%
Ind 2.5.4 B	Core Partner Strategic Topics Redress procedures - all	Number of redress requests	<5%
Ind 2.5.1 B	CfP Topics success rate	percentage of topics resulting in signature of the GAP	>90%
Ind 2.5.4 B	CfP Topics Redress procedures - all	Number of redress requests	<5%

Indicator ID	Indicator short name	Description of indicator	Target set
Ind. 2.7.1 A	WP execution by Members - resources	percentage of resources consumption versus plan (Members only)	>80%
Ind 2.7.1 B	WP execution by Members - deliverables	percentage of deliverables available versus plan (Members only)	>80%
Ind 2.7.3 C	Launch reviews – percentage held	percentage of total major demo activity where Launch Reviews held and resulting in agreed launch of major projects	30%
Ind 2.9 C	Budget execution - payments operational	percentage of payments made within the deadlines	>85%
Ind 3.7.3 A	Budget execution - payments running costs	percentage of payments made within the deadlines	>75%

12. RISK ASSESSMENT

The following table presents the risk assessment of the Clean Sky 2 programme as defined through the risk assessment exercise performed by the JU's management.

Risk Description	CS Process	Action Plan summary
Conflicts of priorities may happen within industrial companies, or change of strategy, resulting in a lack of resources available for Clean Sky 2 and delays in the completion of the activities.	Manage the Programme	Implement a Launch Review for each Project. Have an early warning capability through quarterly reports and alert at Governing Board level. Propose re-orientations when needed and possible.
Technical setbacks in one or several ITDs may result in a significant under-spending of annual budget.	Manage the Programme	Re-balance the budget across ITDs/IADPs and with Partners if necessary at mid-year, according to the 2nd quarterly reports.
The potential introduction of Clean Sky 2 in parallel to Clean Sky may result in a scattering of beneficiaries' resources, a delay in Clean Sky demonstrator's finalization and an overload for the CS team	Manage the Programme	Check resources and any critical dependencies in Launch Reviews. Condition the CS2 funding by ITD and by beneficiary to the actual execution of CS budgets and technical progress
Guidelines for Clean Sky 2 preparation documents may be not clear and/or stable enough, leading to late or incomplete ITD submissions to the JU	Manage the Programme	Have clear management plan and templates for required documentation, defined at the start of the programme.
Core Partner call may be not answered or quality of submissions results in non-selection	Manage the Programme / Manage the Calls	Continue to inform and engage as open a discussion as possible with potential CP Ensure well written description of CP technical activities / Ensure adequate involvement and attention of Industry leaders in the strategic topic definition process
Planning for cost and effort for complex, large ground and flight demonstrators (10 year programme) may lack accuracy	Manage strategic planning risks Deploy lessons learned project	Each IADP / ITD to deploy an individual, tailored risk management and to completion plan
Negotiation processes with Core Partners may be lengthy, leading to delayed start of technical activities	Manage the Programme / Manage the Calls	Ensure appropriate training to Winners and Topic Managers; have a close follow-up of all negotiations and early warning / escalating process for solving issues.

Risk Description	CS Process	Action Plan summary
Efforts for interfaces and cooperation of partners for flight worthy hardware and complex flight demonstrators may be initially underestimated	Manage strategic planning risks Deploy lessons learned project Systematic Design Reviews	Have clear descriptions of work in Call texts for such activities directly related to flight worthy hardware, including requested skills and agreements. Deploy an individual, tailored risk management for interfaces of members and partners for large demonstrator activities Prepare more conservative back-up solutions in advance to mitigate the risk
Competences and resource to successfully enable flight testing may be insufficient	Manage the Programme / Manage the ITDs	Clearly identify the required competences and resources and closely monitor thru PDR/CDR and milestone management. Enforce consistent and robust risk management; implement early-warning system to avoid late discovery of critical path related risks Check relevance of cost and schedule wrt airworthiness issues at Launch Reviews (and further reviews)
The lack of guidelines for inclusion of some Level 2 projects may lead to an unclear perspective and lack of commitment of Members	Manage the Programme / Manage the Calls	Agree strategic priorities with GB. Adapt the technical content. Revise JTP and relevant ITD (IADP), with a target of EoY 2014.
Some costs may be overrun, and some participants may be unable to carry on until completion.	Manage the ITDs	Manage priorities: abandon non crucial technology development and integrate only the crucial ones in the demonstration. Consider the implementation of a contingency margin.

13. JUSTIFICATION OF THE FINANCIAL RESOURCES

Introduction

As Horizon 2020 is the EU funding programme under which the Clean Sky 2 programme will be implemented, the basic funding of the running costs and operational activities is entirely separate to that of the Clean Sky programme. The sources of revenue for 2014 and 2015 as currently set out does not foresee carried over appropriations from previous years, nor interest gained on the bank account of Clean Sky. The only 2 sources of revenue are from the private members (for half of the annual running costs) and the EU subsidy. In total, the running costs will not surpass 80m € when both sources of revenue are combined and are shared 50/50. The available operational budget from the EU subsidy is therefore 1.715bn € (40m € for running costs in addition to this figure).

Running costs

The running costs have been estimated based on Clean Sky implementation while also taking into account the new elements which need to be covered by the CS2 budget only.

The main features of the 2014- 2015 expenditure in the budget are set out below:

Budget Clean Sky 2 Expenditure	Commitment Appropriations 2014	Payment Appropriations 2014	Commitment Appropriations 2015	Payment Appropriations 2015
Title 1	1,682,067	1,682,067	2,172,893	2,172,893
Title 2	842,119	842,119	1,667,397	1,667,397
Title 4	104,857,715	25,000,000	284,052,943	111,174,081
Title 5	0	0	67,778,713	0
Total Budget	107,381,900	27,524,186	355,671,946	115,014,371

Overall allocation of running costs between CS and CS2

It can be noted that the Joint Undertaking's common costs such as electricity, services, postal costs, stationary etc. need to be divided across the 2 programmes. For 2014 the JU allowed to fund the main part of these expenses as the regulation entered into force on the 27th of June 2014. Only those expenses which can directly attributed to the CS2 programme are currently budgeted in the running costs for 2014 in the CS2 annual budget. For 2015, this is revised

further but it has been reduced to meet the reduced commitment and payment appropriations available from the EU subsidy.

Title 1 (Staff and associated costs):

The JU is still defining the staff costs which it can expect in 2014/2015 as a consequence to the establishment plan which will be adopted by the GB in July 2014. The current figures reflect the available commitment and payment appropriations of 2014/2015 for CS2 running costs.

Title 2 (Buildings, IT, Equipment, Communication, Management of Calls and Miscellaneous expenditure for running activities):

Premises

The JU will continue to be housed in the White Atrium as with the other JTIs. In 2014, the JU expects to expand onto the 3rd floor in order to have adequate office space for the 42 staff of the JU and to facilitate the private members' visits to the JU. The expansion is now planned for mid-July 2014 and is the result of a joint effort of all JTIs in the White Atrium to agree on a common sharing of the available space.

Title 3 (Operational Expenditure):

The figures presented here reflect the state of play regarding Leaders, Core Partners and Partners' activities for the years 2014 and 2015.

The overall figures are set out in Title 4 in the budget. In summary, the amounts allocated for Leaders, Core Partners and Partners are reflected here. These amounts are flexible between each other while the total envelope, in particular for PA, is not flexible.

OPERATIONAL EXPENDITURE	2014	2014	2015	2015
	Commitment Appropriations (CA)	Payment Appropriations (PA)	Commitment Appropriations (CA)	Payment Appropriations (PA)
LARGE PASSENGER AIRCRAFT	14,207,014	5,965,534	54,360,506	11,672,365
REGIONAL AIRCRAFT	4,263,753	1,627,359	19,332,764	4,271,780
FAST ROTORCRAFT	5,878,802	3,085,905	18,079,599	5,708,088
AIRFRAME	12,115,208	5,024,629	48,598,111	10,833,667
ENGINES	14,044,728	4,955,060	63,176,122	11,656,013
SYSTEMS	3,794,758	1,916,982	15,406,226	5,305,858
TECHNOLOGY EVALUATOR	18,000	12,785	72,000	44,095
ECO-DESIGN TRANSVERSE ACTIVITY	2,052,924	1,458,193	3,370,076	2,414,572
SMALL AIR TRANSPORT TRANSVERSE ACTIVITY	1,342,462	953,552	1,657,538	1,283,981
CALLS FOR TENDERS	0	0	0	0
CALLS FOR PROPOSAL	47,140,066	0	60,000,000	57,983,663
TITLE 3 - TOTAL	104,857,715	25,000,000	284,052,943	111,174,081
TITLE 5 – UNUSED APPROPRIATIONS	0	0	67,778,713	0
TOTAL TILE 3 & 5	104,857,715	25,000,000	351,831,656	111,174,081

*In order to match the overall level of CA and PA available from the EU subsidy, the Title 5 line 'unused appropriations' is currently allocated the 'leftover' appropriations until the final topic list is available. It is not envisaged to have any part of the available credits 'unused' in any amendment to this Work Plan or annual budget.

PART C – *CLEAN SKY 2 JU – PROGRAMME OFFICE*

14. COMMUNICATION AND EVENTS

Strategy

Key communication activities will include increasing the visibility and reputation of the organisation by conveying JU's achievements, successes and the promotion of Clean Sky 2 Calls for proposals. We will sharpen our message, expand our networks and make our brand visible, consistent and reputed

Clean Sky 2 JU will rely on multipliers and ambassadors:

- Clean Sky 2 Members: industrial leaders and European Commission;
- Local multipliers in the Member States such as States Representative Group (SRG) reaching out to potential applicants;
- Clean Sky project coordinators and participants, who will communicate the successes of Clean Sky to various national and European audiences;
- Clean Sky management and staff and Clean Sky communications network;
- ACARE, reaching out to policy makers inside ACARE companies;

Actions

- a) Attract the best technology in Europe to apply for Clean Sky 2 projects

TARGET GROUPS:	Potential applicants: IADP/ITD leaders, Large, Small and Medium Enterprises, academia
MESSAGE:	Benefits of participation in Clean Sky 2 projects
	Promotion of Calls • Info Days sessions around Call launch • Open Webinar • SRG promotion in each country • Clean Sky management and staff active participation at events • Partnership with SMEs European organisations Clean Sky visibility at key events: • ILA Berlin, Farnborough Air Show 2014 • Paris-Le Bourget on 15-21 June 2015 • ASD Annual event • Clean Sky 2 national events

b) Keep decision makers aware by demonstrating progress of Clean Sky 2

TARGET GROUPS:	Policy-makers in the area of research, innovation, transport and environment in industry and public institutions. Special emphasis on newly elected European Parliament and newly appointed Commission
MESSAGE:	Success of demonstrators in on-going technical projects
	• High-level meetings with national and European policy-makers • High-level media coverage through PR work, press releases and opinion articles in leading and specialised media • Targeted events with representative of European Commission, European Parliament, EU countries Permanent Representations and business community

c) Internal enabler: Support IADP/ITD/TA coordinators and project officers

TARGET GROUPS:	CS ITD coordinators, CS2 IADP/ITD/TA coordinators, project officers
MESSAGE:	Ex-ante and post-project interaction with communications to optimise visibility, advocacy and influence of Clean Sky
	Provide communications guidance and support for their contributions to the web site, events, printed and digital publications as well as other communication tools available.

d) Maximise efficiency and effectiveness of Clean Sky communications efforts.

TARGET GROUPS:	ITD leaders communications professionals, Clean Sky management and staff
MESSAGE:	Maximise internal information and coordinate well external actions while aligning messages and timing
	• Align messages to speak with a single voice at events, high-level meetings and when doing media relations. Improve narrative to reach out various audiences • Coordinate communication activities with Communications network group • Conclude contracts with external communication suppliers where more efficient and needed

15. JU EXECUTIVE TEAM

The JU team of statutory staff consists of 24 positions currently. It is proposed that this team will be increased to 42 statutory positions to manage the two programmes. The establishment plan for 2014 and 2015 shows the increased level. 13 additional positions are envisaged in 2014 while 5 additional posts are envisaged in 2015. Currently the JU manages 325²⁰ grant agreement in addition to the 7 annual grant agreements for members (consisting of 192 beneficiaries financial reports and 7 annual technical reports) As foreseen, the ramp up of the number of grant agreements with partners in place brings a significant burden to the JU to monitor, control and finalise. As the JU moves closer to the demonstrators, many of these grant agreements need to be closed as they deliver the technical activities foreseen.

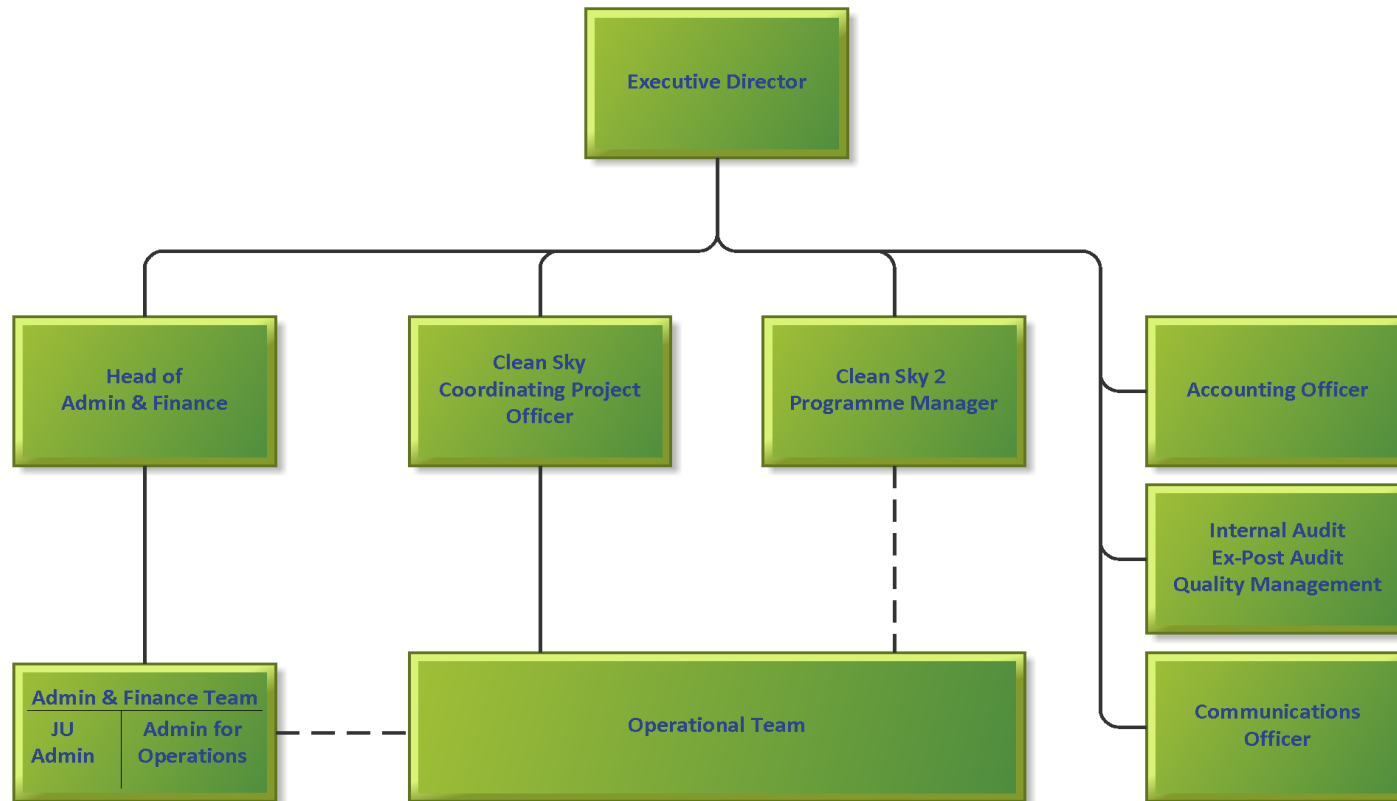
Of the 24 positions currently recruited, 17 positions are involved in the grant management area (excluding senior management tasks). The obligations on the JU to comply with the same financial rules as bigger entities have reached a situation for the JU where it has had to rely on the external service providers and some of its members to provide the team with adequate support.

In the future, with the addition of 18 new positions, 15 of which are for managing purely operational activities, the JU will be in a better position to manage, with its own internal resources both programmes. The future operational team will be composed of project officers supported by a pool of project support officers. This additional element in the operational team will bring much needed support to the overall management of the Programme. In addition, the administrative team will be re-enforced with 2 further financial roles allowing to meet the targets set in H2020 for time to grant and time to pay.

The new organisational structure of the JU is shown below. The structure shows how the 'administration and finance' team works for the most part on the 'operational' files of the JU, i.e. with and for the grant agreements of beneficiaries. The administration of the running costs is a minor task for this team. The structure also shows the functional link from the operational team to the CS2 programme manager.

²⁰ 423 total signed GAPs minus 98 closed projects.

Organisational chart of the JU



16. SUMMARY ANNUAL BUDGET

The Clean Sky 2 Joint Undertaking will manage 2 programmes and therefore, having provided the individual programme budget in the previous chapters, the consolidated annual budget of the Joint Undertaking is set out below. These figures are the addition of the 2 programme elements above. The running costs are shared between the 2 programmes based on the available payment appropriations coming from the EU subsidy.

The detailed Annual Budget for the years 2014 and 2015 of the Clean Sky 2 Joint Undertaking is summarized as follows:

Budget 2014 Clean Sky 2 JU	Commitment Appropriations	Payment Appropriations
Title 1 Expenditures	3,973,734	3,973,734
Title 2 Expenditures	2,377,344	2,377,344
Title 3 Expenditures	92,249,851	122,216,299
Title 4 Expenditures	104,857,715	25,000,000
Title 5 Unused Appropriations	27,640,835	0
Total Budget	231,099,479	153,567,377

Budget 2015 Clean Sky 2 JU	Commitment Appropriations	Payment Appropriations
Title 1 Expenditures	5,247,845	5,247,845
Title 2 Expenditures	2,707,699	2,707,699
Title 3 Expenditures	57,004,482	126,882,462
Title 4 Expenditures	284,052,943	111,174,081
Title 5 Unused Appropriations	67,778,713	0
Total Budget *	416,791,682	246,012,087

17. EX-POST AUDITS

The Ex-post audit (EPA) process represents a significant element of the Internal Control System of the JU.

The main objectives of the audits are:

- 1) Through the achievement of a number of quantitative targets, ensure the legality and regularity of the validation of cost claims performed by the JU's management
- 2) Provide an adequate indication on the effectiveness of the related ex-ante controls
- 3) Provide the basis for corrective and recovery activities, if necessary

FP7 programme

On the basis of the Clean Sky Ex-post audit Strategy for the FP7 programme, as adopted by the CS Governing Board, audits will be performed in the year 2014 and 2015 at the JU's beneficiaries covering mainly cost claims pertaining to the execution of FP7 GAMs of the years 2011 to 2014. The audit activities may also cover FP7 GAPs validated by the JU since the year 2012.

A sample of validated cost claims will be selected covering the following elements:

- Most significant cost claims
- Representative sample selected at random
- Risk based sample

The JU aims to achieve a coverage of 20 to 25% of the operational FP7 expenditure through the ex-post controls.

Audits will be assigned to external audit firms, on the basis of the existing framework contract between the 3 JUs IMI JU, FCH JU and JU. In addition the JUs may make use of a new framework contract, which has been established by the Commission for ex-post audits.

To ensure correct and consistent audit conclusions and results, the JU will closely monitor the execution of the agreed standard audit procedures through the external audit firms. The internal EPA processes of the JU, comprising of planning and monitoring of the audits and implementation of the audit results, will require the input of 3 FTE.

Reported audit results may be (1) qualitative - concerning the internal controls applied by the beneficiaries - and (2) quantitative - expressed in error rates. The ex-post control objective of the JU is expressed in the target of an overall residual error rate²¹ for the entire programme period (FP7) of maximum 2% of total budgetary expenditure.

²¹ The residual error rate represents the remaining level of errors in payments made after corrective measures.

In order to prevent errors in future cost claims of the JU's members the input of the ex-post audit team into the ex-ante validation process will be an important task.

For the final reports of projects under the FP7 programme, the ex-post audit team will develop appropriate audit procedures to cover the specific situation during the operational and financial termination of projects.

The accumulated results of the EPA process during the years 2014 and 2015 will be described in the Annual Activity Reports and will be considered for the assurance declarations of the Executive Director for the two years.

H2020 programme

The first audits of H2020 grant agreements are not planned before 2016. Until then, the JU Ex-post Audit Strategy needs to be developed in reconciliation with the Commission. A specific monitoring and review process regarding the methodology applied for the evaluation of the in-kind contribution reported by the JU Members and Core Partners will be developed.

18. PROCUREMENT AND CONTRACTS

Procurement

For the year 2014-2015 the JU will assign the necessary funds for the procurement of the required services and supplies in order to sufficiently support its administrative and operational infrastructures.

From its autonomy, the JU has efficiently simplified the procurement process by establishing multi-annual framework contracts and Service Level Agreements for the supply of goods and services and by joining inter-institutional tenders and joint tenders with the European Commission and other Joint Undertakings to reach optimization of resources.

In 2014-2015 only few new calls for tenders are expected to be launched due to the fact that some framework contracts will start running at end of 2013 for a 3 or 4 year duration. The tenders planned to be launched in 2014-2015 are expected to support some core activities mainly in the field of communication for specific events and activities and in the IT field.

The start of the operational activities of JU and the planned increase of staff of the JU will require an extension of the current office allocation at the White Atrium Building which is planned to be dealt with through a joint amendment procedure of the existing building rental contract by the affected Joint Undertakings.

A summary table is made available below listing the tenders planned for 2014-2015 and the procurement procedure expected to be used at this stage on the basis of the information currently available, estimated budget and estimated timetable for publication. Only tenders with a value exceeding EUR 5.000 are listed in the following table.

Contracts to be tendered in 2014 and 2015²²

Title indicative	Expenditure indicative	Type of procedure	Schedule indicative
IT infrastructure services			
IT infrastructure and hardware including management and maintenance services	130.000 EUR	Open procedure (Joint procedure with other JUs)	Launch planned for 2 nd quarter 2014
Communication related activities and events			
Organisation of stand at the Farnborough Air Show	< 60.000 EUR	Negotiated procedures with three tenderers ²³	Launch planned for 1 st /2 nd quarter 2014
Organisation of stand at the ILA Berlin Air Show	< 60.000 EUR	Negotiated procedures with three tenderers ²⁴	Launch planned for 1st quarter 2014
Organisation of stand at Paris Le Bourget Air Show	< 60.000 EUR	Negotiated procedures with three tenderers ²⁵	Launch planned for 1st quarter 2015

²² Estimate

²³ This procedure will be launched in case the recourse to Framework Contract (CSJU.2013.OP.01 Lot3) for communication and events organization could not be used in the light of the specific services required and the location of these events.

²⁴ *Idem*

²⁵ *Idem*

19. DATA PROTECTION

In 2014-2015, the JU will continue to ensure that personal data are protected and that Regulation (EC) No 45/2011 is complied with, by implementing the following actions:

- ✓ The JU Data Protection Officer will allocate time in advising and /training the staff in particular in relation to the implementation of the accountability principle and to the follow-up in specific fields of the thematic guidelines issued by the European Data Protection Supervisor;
- ✓ The JU will continue to implement the internal procedure for handling internal notifications under Article 25 of Regulation (EC) No 45/2011 related to administrative processing operations by the JU's staff and, where applicable, to the prior checking notifications to the EDPS under Article 27 of Regulation (EC) No 45/2011.
- ✓ The JU will implement the data protection aspects related to the launch and management of the calls for proposals in accordance with the rules and procedures of Horizon 2020.

In the light of the General Monitoring Report for the year 2013 carried out by the JU in a comprehensive way and duly notified to the EDPS, the JU will ensure adequate follow up to any pending notification or any complement of information requested by the EDPS in the light of the latest prior checking notifications submitted to EDPS by the end of 2013 such as the notifications on procurements, grants and experts, on the treatment of health data and on the conflicts of interest and the related declarations of interests.

- ✓ The JU will also take note of the EDPS Report expected in 2014 and of any recommendation addressed to the JU.
- ✓ Follow-up in EDPS meetings on the EU legal framework for data protection and potential impact on EU Institutions/Agencies/JUs of the data protection package proposal, along with any guidelines and training provided by EDPS on specific areas such as the impact of technological developments on personal data protection, IT, websites etc.

ANNEXES

20. ANNEX I –1st Call for Core-Partners: List and Full Description of Strategic Topics

(See end of document)

21. ANNEX II - Annual Budget 2014-2015

(Available in separate document)

22. GENERAL ANNEXES OF THE WORK PLAN

A. List of countries, and applicable rules for funding for Calls for Core Partners

Legal entities established in the following countries and territories will be eligible to participate and receive funding as Core Partners of Clean Sky 2 JU selected through calls for Core Partners:

- The Member States of the European Union, including their overseas departments;
- The Overseas Countries and Territories (OCT) linked to the Member States²⁶:
 - Anguilla, Aruba, Bermuda, Bonaire, British Virgin Islands, Cayman Islands, Curaçao, Falkland Islands, French Polynesia, Greenland, Montserrat, New Caledonia, Pitcairn Islands, Saba, Saint Barthélemy, Saint Helena, Saint Pierre and Miquelon, Sint Eustatius, Sint Maarten, Turks and Caicos Islands, Wallis and Futuna.
- The Countries Associated to Horizon 2020²⁷: the latest information on which countries are associated, or in the process of association to Horizon 2020 can be found in the online manual²⁸.

International European interest organisations²⁹ will also be eligible to receive funding from Horizon 2020.

²⁶ Entities from Overseas Countries and Territories (OCT) are eligible for funding under the same conditions as entities from the Member States to which the OCT in question is linked

²⁷ Signed an agreement with the Union as identified in Article 7 of the Horizon 2020 Regulation

²⁸ http://ec.europa.eu/research/participants/docs/h2020-funding-guide/cross-cutting-issues/international-cooperation_en.htm

²⁹ These are international organisations, the majority of whose members are Member States or associated countries, and whose principal objective is to promote scientific and technological cooperation in Europe.

B. Admissibility conditions and related requirements for Calls Core Partners

1. To be considered admissible, an application for Core Partner must be:

- (a) Submitted in the electronic submission system before the deadline given in the call conditions;
- (b) Readable, accessible and printable.

2. Incomplete applications for Core Partner may be considered inadmissible. This includes the requested administrative data, the application description, and any supporting documents specified in the call.

3. Operational capacity – requested inputs

The following will be required to determine the operational capacity of an applicant for Core Partner, unless otherwise specified:

- curriculum vitae or description of the profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities;
- the applicant³⁰ reports of research and development activities, products, services executed in the same relevant area;
- a lists of previous projects and activities performed and connected to the topic and Programme area;
- a description and evidences of the key capabilities of the entity, significant infrastructures, technical equipment, design and test tools, facilities, design offices patents and other IP rights at the disposal of the applicant;
- Other inputs to assess the operational capacity as requested in the topic description in the Call;
- A description of any third parties (including affiliates³¹) and their contribution to the action that are not represented as applicants, but who will nonetheless be contributing towards the work (e.g. providing facilities, computing resources).

4. Applications for Core Partners shall include a draft plan for the exploitation and dissemination of the results. The section on exploitation shall be showing and committing on a clear exploitation path of the results brought by their participation in the Programme showing the contribution to European competitiveness of the sector. The JU will check this

³⁰ In the case of legal entities forming one applicant (clusters) the above requirements apply to the Cluster as such and to those entities composing the cluster.

³¹ See the definition under Article 2 of H2020 Rules for Participation

aspect at evaluation stage and reserves the right to check this aspect also during the implementation stage.

5. Page limits will apply to applications for Core Partners. The limits will be clearly set out in the electronic submission system. If a submitted application exceeds the limits, the applicant will receive an automatic warning, and will be advised to re-submit a version that conforms. After the relevant call deadline, excess pages in any over-long application will be automatically overprinted with a “watermark”. Expert evaluators will be instructed to disregard these excess pages.

6. In the light of the specific structure of the Programme and the governance framework of the JU, the specific legal status and statutory entitlements of the “Members” of the JU and in order to prevent any conflict of interest and to ensure a competitive, transparent and fair process, the following specific admissibility rules shall apply to the calls:

- **The 16 Leaders of JU listed in Annex II to Regulation n° (EU) No 558/2014 and their affiliates**³² may apply to Calls for Core Partners and Calls for Proposals only in another IADP/ITD where they are not involved as Members. In case of selection of Leaders and their affiliates as Core Partners or Partners in the Programme, their participation will be accounted by the JU within the **40% budget share of the programme allocated to the Leaders** thereto Article 16.1 a) of the Statutes, therefore without any impact on the 30% budget share allocated to the Core Partners thereto Article 16.1 b) of the Statutes.
- **The Core Partners and their affiliates** may apply in subsequent waves of Calls for Core Partners in all IADP/ITD. They may apply to Calls for Proposals only in another IADP/ITD where they are not involved as Members.
- **The Partners** selected by Call for Proposal may apply to Calls for Core Partners and Calls for Proposal in all IADP/ITD.

All applicants will be requested in the application submission forms to:

- officially state whether they are an affiliate³³ to a Member of the JU;
- to issue a declaration of absence of conflicts of interest³⁴ that will determine its admissibility.

The above criteria and the declarations will be checked by the JU which will determine

³² See the definition under Article 2.1 of H2020 Rules for Participation

³³ Applicants shall check the definition based on Article 2.1 of H2020 Rules for Participation

³⁴ As part of the declaration, the legally authorized representative of the applicants entities will be requested to declare whether the representative(s) of the entity participate to the IADP/ITD steering committees and whether they representative(s) of the entity was involved in the preparation, definition and approval of the topics of the calls.

the admissibility of the applicants for Core Partners. The CSJU reserves its right to request any supporting document and additional information at any stage of the process.

Special condition for participation applicable to Core Partners

7. Pursuant to Article 4 of the Statutes, Annex I of Regulation n. 558/2014, a legal entity may apply to become a Core Partner provided that it contributes to the funding referred to in Article 15 of the Annex I of the Regulation to achieve the objectives of the CSJU set out in Article 2 of the Regulation and it accepts the Statutes of the CSJU.

Based on the above, applicants to the Calls for Core Partners shall declare, at the application stage, a commitment to endorse the Statutes and its provisions. The formalization of the acceptance of the Statutes by formal endorsement letter will be made upon selection of the applicants as part of the negotiation stage.

C. Eligibility criteria for Calls for Core Partners

An application as Core Partner will only be considered eligible if:

- 1) its content corresponds, wholly or in part, to the topic description against which it is submitted, in the relevant work plan part;
- 2) submitted by a legal entity established in a Member State or H2020 associated country;
- 3) submitted by a Consortium³⁵ of legal entities established in a Member State or H2020 associated country jointly applying to become individual Members.
- 4) submitted by a Cluster as single legal entity established in a Member State or H2020 associated country.³⁶

³⁵ When a group of legal entities apply jointly as Consortium, its members are all requested singularly to become a Member of CSJU and sign the Grant agreement for Members. In this case, all entities become beneficiary in the sense of the Grant agreement for Members and are bound directly by its provisions.

³⁶ See section Joint applications by legal entities in the *Rules for submission, evaluation, selection, award and review procedures of Calls for Core Partners.*

D. Types of action: specific provisions and funding rates^{37,38}

Research and innovation actions³⁹

Description: Action primarily consisting of activities aiming to establish new knowledge and/or to explore the feasibility of a new or improved technology, product, process, service or solution. For this purpose they may include basic and applied research, technology development and integration, testing and validation on a small-scale prototype in a laboratory or simulated environment.

Projects may contain closely connected but limited demonstration or pilot activities aiming to show technical feasibility in a near to operational environment.

The activities performed will not exceed TRL 6.

Funding rate: 100%

Innovation actions

Description: Action primarily consisting of activities directly aiming at producing plans and arrangements or designs for new, altered or improved products, processes or services. For this purpose they may include prototyping, testing, demonstrating, piloting, large-scale product validation and market replication.

The activities performed will not exceed TRL 6.

Funding rate: 70% (except for non-profit legal entities, where a rate of 100% applies)

Coordination and support actions

Description: Actions consisting primarily of accompanying measures such as standardisation, dissemination, awareness-raising and communication, networking, coordination or support services, policy dialogues and mutual learning exercises and studies, including design studies for new infrastructure and may also include complementary activities of strategic planning, networking and coordination between programmes in different countries.

Funding rate: 100%

³⁷ Eligible costs for all types of action are in accordance with the Financial Regulation and the Rules for Participation. In addition, as training researchers on gender issues serves the policy objectives of Horizon 2020 and is necessary for the implementation of R&I actions, applicants may include in their proposal such activity and the following corresponding estimated costs that may be eligible for EU funding:

- i. Costs of delivering the training (personnel costs if the trainers are employees of the beneficiary or subcontracting if the training is outsourced);
- ii. Accessory direct costs such as travel and subsistence costs, if the training is delivered outside the beneficiary's premises;
- iii. Remuneration costs for the researchers attending the training, in proportion to the actual hours spent on the training (as personnel costs).

³⁸ Participants may ask for a lower rate.

E. Technology readiness levels (TRL)

Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

- TRL 1 – basic principles observed
- TRL 2 – technology concept formulated
- TRL 3 – experimental proof of concept
- TRL 4 – technology validated in lab
- TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- TRL 7 – system prototype demonstration in operational environment
- TRL 8 – system complete and qualified
- TRL 9 – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

F. Evaluation of Calls for Core Partners

Selection Criteria

a) *Financial capacity*: In line with the Financial Regulation, at the proposal stage, applicants for Core Partners will be invited to complete a self-assessment using an on-line tool. The CSJU may perform a risk assessment based on the financial information provided by the applicant. This will apply also to the entities composing a grouping in case of applications submitted by groupings jointly applying as a one entity⁴⁰.

b) *Operational capacity*: As a distinct operation, experts will indicate whether the participants meet the selection criterion related to operational capacity (as described in section B 3 above), to carry out the proposed work, based on the capabilities, competence and experience of the individual participant(s).

Award criteria

Experts will evaluate the applications on the basis of the criteria ‘excellence’, ‘impact’ and ‘quality and efficiency of the implementation’. The aspects to be considered are set out in the table below, unless stated otherwise in the call.

Type of action	Excellence	Impact	Quality and efficiency of the implementation
	The following aspects will be taken into account, to the extent that the proposed work corresponds to the topic description in the work plan.	The extent to which the outputs of the project should contribute at the European and/or International level to:	The following aspects will be taken into account:
Research and innovation; Innovation;	- Relevance and adequacy of the required key capabilities, competences and track record in the relevant topic area and experience with respect to the Topic (e.g. capability to efficiently contribute to a permit-to-fly application) and the overall level of key capabilities required to implement the Programme; - Clarity and pertinence	- Level of technical contribution and key capabilities brought to the IADP/ITD and Programme objectives - The expected impact as described under the relevant topic and the strategic contribution brought to the Programme and the; - Enhancing innovation capacity and integration of new knowledge;	- Consistency of the proposed activity with the background, skills and competences as described; - Coherence and effectiveness of the application, including appropriateness of the allocation of tasks and resources; - Appropriateness of the management structures and procedures, including risk and innovation

⁴⁰ See footnote 15

	of the objectives; - Credibility of the proposed approach; - Soundness of the concept, including trans-disciplinary considerations, where relevant; - Relevance and adequacy of proposed work and results as compared with the Topic description; - Extent that proposed work is ambitious, has innovation potential, and is beyond the state of the art (e.g. ground-breaking objectives, novel concepts and approaches) - Suitability of the technologies, approaches and solutions proposed, including the complementary activities, where applicable, with respect to the Topic description and the IADP/ITD area and objectives.	- Strengthening the competitiveness and growth of companies by developing innovations meeting the needs of European and global markets, and where relevant, by delivering such innovations to the markets; - Demonstrating the environmental and socially important impacts as relevant for the CS2 Programme; - Performance of the “core research” activities within Europe and Associated Countries; - Plan on exploitation of results showing the contribution on the European competitiveness in the sector; - Effectiveness of the proposed measures to exploit and disseminate the project results (including management of IPR), to communicate the project, and to manage research data where relevant; - Level of strategic contribution and key capabilities brought to the IADP/ITD and Programme objectives; - Probability of application/valorization of technology results, including soundness of the exploitation plan and its ability to contribute to the competitiveness of the sector.	management; - Match of technical capabilities and skills with the Topic and Programme objectives; - strategic ability to work in the topic area; - Coordinating capability in the supply chain and ability to work effectively both with a supply base and into an equal or higher tier industrial organization as integrator/leader; - Capability and management skills for Calls for Proposal coordination, when acting as Topic Manager (where applicable); - Clear demonstration of adequate level of financial and operational resources (committed) based on the Topic value indicated in the call and the overall Programme needs; - Best “value for money” on the activities proposed and efficiency of the allocation of resources; - Complementarity of the participants within the consortium or cluster (where applicable); - Capacity of the cluster or consortium or leader to efficiently coordinate activities of the participants (where applicable).
Coordination & support actions	Clarity and pertinence of the objectives; Credibility of the proposed approach; Relevance and adequacy of proposed work and results as compared with the Topic description;	The expected impacts listed in the work programme under the relevant topic Effectiveness of the proposed measures to exploit and disseminate the project results (including management	Coherence and effectiveness of the work plan, including appropriateness of the allocation of tasks and resources; Complementarity of the participants within the consortium (when

	Soundness of the concept; Quality of the proposed coordination and/or support measures.	of IPR), to communicate the project, and to manage research data where relevant.	relevant); Appropriateness of the management structures and procedures, including risk and innovation management.

Note: Unless otherwise specified in the call conditions:

Evaluation scores will be awarded for the criteria, and not for the different aspects listed in the above table. Each criterion will be scored out of 5. The threshold for individual criteria will be 3. The overall threshold, applying to the sum of the three individual scores, will be 10.

Complementary activities

If an applicant as Core Partner considers that it has different applications or different technologies or innovative solutions to propose in relationship to one topic, the applicant should present them in the same single application as “complementary activities” in the relevant section of the submission forms (description and budget).

If the applicants indicate complementary activities and innovative solutions within the general topic area related to the topic for which they are applying and within the scope of the IADP/ITD, they should demonstrate that these activities would:

- be in line with Clean Sky 2 Programme key goals and objectives;
- represent an enhancement or improvement of the content of an IADP/ITD and
- lead to a demonstrable additional move beyond the state of the art in the topic’s general area.

Complementary activities will be evaluated by the independent experts in the framework of the topic evaluation process as indicated by the evaluation criteria mentioned above. However, the inclusion of these complementary activities in any subsequent grant will be subject to the CSJU Governing Board approval and CSJU funding availability.

Priority order for applications with the same score

Unless the call conditions indicate otherwise, the following method will be applied.

As part of the evaluation by independent experts, a panel review will recommend one or more ranked lists for the applicants under evaluation, following the scoring systems indicated above. A ranked list will be drawn up for every indicative budget shown in the call conditions.

If necessary, the panel will determine a priority order for applications which have been awarded the same score within a ranked list. Whether or not such a prioritisation is carried out will depend on the available budget or other conditions set out in the call text. The following approach will be applied successively for every group of *ex aequo* proposals requiring prioritisation, starting with the highest scored group, and continuing in descending order:

- (i) Applications that address topics not otherwise covered by more highly-ranked applications will be considered to have the highest priority.

(ii) These proposals will themselves be prioritised according to the scores they have been awarded for the criterion *excellence*. When these scores are equal, priority will be based on scores for the criterion *impact*. In the case of Innovation actions, and the SME instrument (phases 1 and 2), this prioritisation will be done first on the basis of the score for *impact*, and then on that for *excellence*.

If necessary, any further prioritisation will be based on the following factors, in order: size of budget allocated to SMEs; gender balance among the personnel named in the proposal who will be primarily responsible for carrying out the research and/or innovation activities.

If a distinction still cannot be made, the panel may decide to further prioritise by considering how to enhance the quality of the project portfolio through synergies between projects, or other factors related to the objectives of the call or to Horizon 2020 in general. These factors will be documented in the report of the Panel.

(iii) The method described in (ii) will then be applied to the remaining *ex aequo* in the group.

G. Budget flexibility

Budgetary figures given in this work plan are indicative and are based on an estimate of the topic values and the CSJU funding per topic. Unless otherwise stated, final funding may vary following the evaluation of the applications and the negotiation stage.

The funding values shall not be confused with the total topic value. The funding value corresponds to the average funding calculated by the JU based on the experience in the Clean Sky programme. The final funding value per topic will entirely depend on the cost structure of the winning entity, the funding rate, and the scope of work proposed in their application.

23. List of abbreviations

AB: Annual Budget

ACARE: Advisory Council for Aeronautics Research in Europe

AIP: Annual Implementation Plan

ATM: Air Traffic Management

CA: Commitment Appropriations

CDR: Critical Design Review

CfP: Call for Proposals

CfT: Call for Tender

CROR: Counter Rotating Open Rotor

JU: Clean Sky Joint Undertaking/ Clean Sky 2 Joint Undertaking

EC: European Commission

ECO: Eco-Design

EDA: Eco-Design for Airframe

GAM: Grant Agreement for Members

GAP: Grant Agreement for Partners

GRA: Green Regional Aircraft

GRC: Green Rotorcraft

IAO: Internal Audit Officer

ITD: Integrative Technology Demonstrator

IADP: Innovative Aircraft Demonstrator Platform

JTP: Joint Technical Programme

PA: Payment Appropriations

PDR: Preliminary Design Review

QPR: Quarterly Progress Report

SAGE: Sustainable and Green Energy

SESAR: Single European Sky Air Traffic Management Research

SFWA: Smart Fixed Wing Aircraft

SGO: Systems for Green Operation

SPD: System & Platform Demonstrator

TA: Transversal Activity

TE: Technology Evaluator

TP: Technology Products

TRL: Technology Readiness Level

WP: Work Package

ANNEX I

1st Call for Core-Partners: List and Full Description of Topics

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List of Topics for Core-Partners

Identification	Title	Topics	Value (Funding in M€)
JTI-CS2-2014-CPW01-LPA		8	53
JTI-CS2-2014-CPW01-LPA-01-01	Advanced Engine and Aircraft Configurations		15
JTI-CS2-2014-CPW01-LPA-01-02	Integrated Flow Control Applied to large Civil Aircraft		4
JTI-CS2-2014-CPW01-LPA-01-03	Advanced HLFC Fin Design Work		5
JTI-CS2-2014-CPW01-LPA-01-04	Integrated Engine Mounted Rear End Demonstrator: Component Design, Manufacturing and Test		7,5
JTI-CS2-2014-CPW01-LPA-01-05	PoWer Turbine of the Flight Demonstrator Contra Rotative Open Rotor (CROR) engine		5
JTI-CS2-2014-CPW01-LPA-01-06	Rotating Frames of the flight demonstrator CROR engine		5
JTI-CS2-CPW01-LPA-02-01	Airframe Cabin and Cargo and System integration Architecture		5
JTI-CS2-CPW01-LPA-02-02	Cabin & Cargo Functional System and Operations		6,5
JTI-CS2-CPW01-REG		3	18
JTI-CS2-2014-CPW01-REG-01-01	Development of advanced systems technologies and hardware/software for the Flight Simulator and Iron Bird ground demonstrators for regional aircraft		5
JTI-CS2-2014-CPW01-REG-01-02	Advanced wing for regional A/C - Technologies Development, Design and Manufacturing for FTB#1		6
JTI-CS2-2014-CPW01-REG-02-01	Flight Physics and wing integration in FTB2		7
JTI-CS2-CPW01-FRC		2	14
JTI-CS2-2014-CPW01-FRC-02-01	LifeRCraft Airframe		7,5
JTI-CS2-2014-CPW01-FRC-02-02	LifeRCraft Drive System		6,5

Identification	Title	Topics	Value (Funding in M€)
JTI-CS2-2014-CPW01-AIR		6	46
JTI-CS2-2014-CPW01-AIR-01-01	New Innovative Aircraft Configurations and Related Issues		16,5
JTI-CS2-2014-CPW01-AIR-01-02	Optimised Ice Protection Systems Integration in Innovative Control Surfaces		5
JTI-CS2-2014-CPW01-AIR-02-01	New Wing and Aircraft Systems Design and Integration for Turboprop Regional Aircraft		5
JTI-CS2-2014-CPW01-AIR-02-02	Out of Autoclave Composite Manufacturing, Wing and Tail Unit Components and Multifunctional Design		7,5
JTI-CS2-2014-CPW01-AIR-02-03	Advanced Technologies for More Affordable Composite Fuselage		6,5
JTI-CS2-2014-CPW01-AIR-02-04	Design and Manufacturing of an Advanced Wing Structure for Rotorcraft Additional Lift		5,5
JTI-CS2-2014-CPW01-ENG		8	64,5
JTI-CS2-2014-CPW01-ENG-01-01	Low Pressure Turbine Rear Frame (LP TRF) and Low Pressure Spool Shaft (LPS) for Ultra High Propulsive Efficiency (UHPE) Demonstrator for short / Medium Range Aircraft (WP2)		5
JTI-CS2-2014-CPW01-ENG-01-02	Power GearBox (PGB) for Ultra High Propulsive Efficiency (UHPE) Demonstrator for Short/Medium Range Aircraft		5
JTI-CS2-2014-CPW01-ENG-01-03	Business Aviation / Short Regional TP demonstrator Front Power Plant Module		6,5
JTI-CS2-2014-CPW01-ENG-02-01	Aerodynamic Design and Testing of advanced Geared Fan Engine Modules		6
JTI-CS2-2014-CPW01-ENG-02-02	LPC, ICD and TEC development for next generation geared fan engines		7
JTI-CS2-2014-CPW01-ENG-03-01	VHBR Engine - IP Turbine Technology		20
JTI-CS2-2014-CPW01-ENG-03-02	VHBR Engine Structural Technology		5
JTI-CS2-2014-CPW01-ENG-04-01	More advanced and efficient small turbine engines for SAT market		10

Topics for Core-Partners Call 1



Identification	Title	Topics	Value (Funding in M€)
JTI-CS2-2014-CPW01-SYS		2	10
JTI-CS2-2014-CPW01-SYS-02-01	Power Electronics and Electrical Drives		5
JTI-CS2-2014-CPW01-SYS-03-01	Model, tools, simulation and integration		5

Clean Sky 2 – Large Passenger Aircraft IAPD

I. Advanced Engine and Aircraft Configurations

Leader and Programme Area [SPD]	LPA		
Work Packages (to which it refers in the JTP)	WP 1.1, 1.2, 1.6		
Indicative Topic Funding Value	15 M€		
Leading Company	Airbus		
Duration of the action	9 years	Start Date	1 st April 2015
Date of Issue	05 th June 2014	Call Wave	1

Topic Number	Title		
JTI-CS2-2014-CPW01-LPA-01-01	Advanced Engine and Aircraft Configurations <i>Preparation, execution and analysis of flight test targeting the demonstration of innovative engine concepts</i> <i>This Strategic Topic encompasses 7 main areas of activities (“Modules”) in LPA Platform 1, see table below</i>	Duration	9 years
		Start Date	1 st April 2015

1. Background

The purpose of the present topic description is to find Core-Partner(s) in LPA who contribute on a strategic and architecture level to a wide scope of research activities in overall aircraft design for large passenger aircraft. The overall volume of this Topic, the multidisciplinary activities to be performed as well as the broad portfolio of various high-fidelity skills and capabilities required, are such that application from small cluster / consortia is encouraged. For reasons of simplification, the following text will only use the wording Core-Partner(s).

It is expected that the Core-Partner(s) provides all necessary capabilities, skills and resources to perform technology development on high Technology Readiness Level in a large European research platform. The successful applicant(s) of this Topic contributes to the development of advanced and fully integrated propulsion development primarily in close collaboration with Airbus, Snecma and other dedicated Core-Partners.

Furthermore, the principle of operation requires strong experience in working in a multidisciplinary and integrated design environment. The role of the successful applicant(s) to this topic will be also to bring an essential contribution to the technical management and further program planning. The coordination of other contributing partners in the course of the programme is an explicit part of the scope of this topic.

The role in this topic is explicitly founded on a number of fundamental and long termed contributions to demonstrators and technologies in LPA Platform 1.

For the sake of clarity, these specific hot spots of work are broken down by “Modules”, with an indicative value of the expected amount of work. The 7 modules are as follows:

All seven Modules in this topic are aiming to identify and develop innovative integration solutions for either contra rotating open rotor engines (Module A-D), future large by-pass ratio turbofan engines (Module E,F), and at even more radical, hybrid propulsion solutions (Module G) for future Large Passenger Aircraft. The scope of powerplant integration activities cover the maturation of design solutions including flight testing or ground testing and the development of new capabilities to enable those demonstrations in the most efficient manner. This includes the numerical and experimental simulation and definition of the aerodynamic and acoustic performance as well as the aeroelastic characterization of the intergated powerplant concept. Another gravity lies on the execution and analysis of experiments and demonstrations (all seven Modules).

Module/ Indicative share of total CP activity	Title
Module A ~10%	Aero-acoustic measurements and transposition <i>linked to:</i> LPA WP1.1 CROR demo-engine Flight Test Demonstration (FTD) – In Flight CROR demonstration
Module B ~15%	Pre and post-flight aero-acoustic characterisation <i>linked to:</i> LPA WP1.1 CROR demo-engine Flight Test Demonstration (FTD) – In Flight CROR demonstration
Module C ~20%	Testing and validation of the dynamic and impact behavior of an advanced fuselage rear end <i>linked to:</i> LPA WP1.2 Advanced engine integration driven fuselage CFRP Rear End Large Scale Demonstration of Rear Fuselage mounted Engine Configuration
Module D ~20%	Vibro-acoustic characterisation and structural impact <i>linked to:</i> LPA WP1.2 Advanced engine integration driven fuselage CFRP Rear End Large Scale Demonstration of Rear Fuselage mounted Engine Configuration
Module E ~15%	Aero-acoustic measurements and characterization <i>linked to:</i> LPA WP1.6 Demonstration of Radical Aircraft Configurations Turbofan FTD – Next Generation Large Engine Demonstration
Module F ~10%	Pre and post-flight aero-acoustic characterisation <i>linked to:</i> LPA WP1.6 Demonstration of Radical Aircraft Configurations Turbofan FTD – Next Generation Large Engine Demonstration
Module G ~10%	Design and Analysis of a Novel Propulsion Architecture, “Competitive Concept Design” <i>linked to:</i> WP1.6 Demonstration of Radical Aircraft Configurations Aircraft Configuration Development for Alternative Propulsion Concepts

The current description (including work content and objectives) define the activities in relation within the existing work packages (incl. nomenclature) as defined in the Joint Technical Proposal (JTP), version 4, as the baseline document (refer to Figure 1 below).

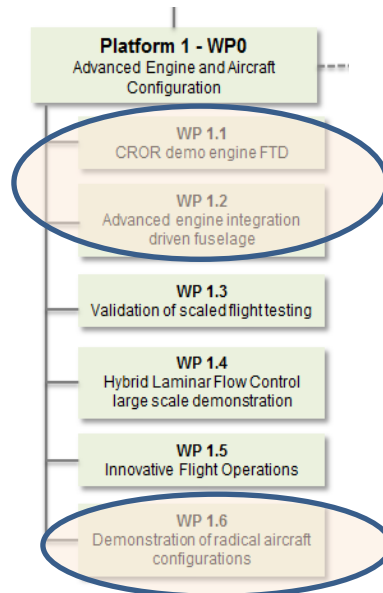


Figure 1. Demonstrators and main work packages in LPA Platform1 addressed in this Strategic Topic (see also complete LPA WBS in JTP_v4)

The Core-Partner(s) to be identified for this topic shall take a strategic role in each of the modules. Even though the technical work described in the modules is typically connected to a technical demonstrator roadmap of less than the full duration of Clean Sky 2, the involvement of the selected Core-Partner(s) shall go beyond, by addressing potential reorientations in the program due to specific achievements, the outcome of decision gates, or due to manage specific risks. With the application to this topic, the proposing candidate shall be ready to make a commitment for an engagement to the full program lifetime of LPA.

Explicitly included in all the Modules of this Topic is the readiness to take responsibility in the technical lead of action, through leading work packages or sub work packages, and the definition of topics for Call of Proposal(s) of partners.

2. Overall Scope of Work

As explained in the background chapter, the activities in this topic are assigned through seven Modules to specific main areas of activities which are assigned to the LPA WBS. In the following, the related descriptions are provided by each of the seven modules.

a) Module A

Aero-acoustic measurements and transposition

linked to:

LPA WP1.1 CROR demo- engine FTD – “In Flight CROR demonstration”

▪ Short description

The CROR propulsion technology is the key contributor to the overall aircraft package that can offer an improvement in fuel burn efficiency in the order of 15% - 20% compared to the best today's technology status. With best performance at cruise speed of Ma0.72 to Ma0.76, a huge amount of joint R&T activities to develop and integrate the CROR engine concept for short and medium haul large transport aircraft have been launched in Clean Sky since July 2008.

Despite significant progress to develop and mature the CROR propulsion technology made in previous research programs addressing the issues of certification, cabin and community noise, as well as various aspects of the propulsion system integration and the engine design, a major flight test campaign with a full sized flight-worthy engine is still THE yet missing key contribution to be able to accomplish the the very ambitious overall programme target to for TRL 6.

The scope of this Module is related to activities supporting the in-flight demonstration of a CROR Engine.

The major objectives to be tackled by the Core-Partner(s) are as follows:

- Validate the aerodynamic efficiency versus noise level for a full size integrated CROR pusher engine under operational conditions including interaction with pylon wake
- Demonstrate and validate the viability of assumptions for the chosen engine concept like power gearbox, blades, pitch control, lubrication system, energy and thermal management, engine control concept. The domains that will be analysed for engine benefits are dynamic and mechanical behaviour, operability and transients over the whole flight profile, vibrations, blade noise characteristics at aircraft scale with installation effects, etc.
- Demonstrate and validate a pylon concept and system integration, in particular addressing loads, vibration, and noise attenuation technologies in real size
- Demonstrate and validate the selected propeller and blade design

- Synthesize available data from Clean Sky with CROR demo-engine flight test data, re-calibrate tools analysis and converge results to accomplish TRL 6



Figure 2. Airbus R&T concept study with rear mounted open rotor engines

The activity is aiming at studying both the aerodynamics and acoustics properties of the current and future CROR engine definition.

For both domains, a list of activities have already been identified as per described below. This, yet not exhaustive list, will be complemented during the execution of the programme in the light of achievements and progresses. In the proposal the core-partner candidate shall demonstrate how he will tackle the listed activities together with additionally proposed activities that are deemed potentially relevant in this context. The benefits and the contribution to the overall objectivities shall be given.

Aerodynamics related to CROR FTD activities

- Blade deformation computation and evaluation – Instrumentation setup development
- Transition prediction evaluation - Instrumentation setup development
- 1P loads and moments prediction
- Flow field effect: Assess propeller robustness to inflow disturbances – Measurement techniques in the volume setup development
- Installation effect transposition from FTD CROR to CROR A/C through numerical methods
- Installation effect transposition from FTD CROR to CROR A/C through WTT
- Characterization of vibration source on FTD configuration:
 - Characterization of vibrations for operational flight: definition and set-up instrumentation and analysis
 - Characterization of vibrations for FTD configuration:
 - inflow impact: wing wake, spoiler deflection, high alpha & high sideslip effect
 - Toe & Tilt effect

- high angle of attack with flow separation on the wing
 - high sideslip effect
 - spoiler deployment effect
- Characterize the slipstream effect on rear end: HTP and VTP buffeting
- Characterize vibrations without wind:
 - assess ground vibration
 - Specific tests on ground to qualify vibrations without wind
- Characterization of the flutter A/C and whirl flutter (propeller effect)

Acoustics related to CROR FTD activities and complementary Wind Tunnel Tests

- Instrumentation for Wind Tunnel Tests (WTT) and Flight Test Demonstration (FTD)
 - On ground instrumentation for flyover tests
 - Development of CROR FTD CROR specific on ground instrumentation development
 - FTD
 - FTD CROR specific aircraft acoustic instrumentation development (source separation through array processing, instrumentation to characterize TBL noise...)
 - Separation through array processing, instrumentation to characterize TBL noise...)
- En Route Noise (ERN), operational noise (noise on ground)
 - Numerical simulations of ERN, and operational noise (source, propagation, annoyance)
 - Re-evaluation of current fleet noise on ground after 2020 (similar to BANOERAC), possibly through a dedicated Partner through a CfP
- FTD CROR related activities
 - Chase aircraft
 - Development of chase A/C for acoustic measurement (microphones on A/C skin or in a nose boom...)
 - Installation effect transposition from FTD CROR to CROR A/C through numerical methods
 - CFD/CAA simulation of FTD & baseline CROR aircraft supporting pre and post-test analysis
 - Installation effect transposition from FTD CROR to CROR A/C through WTT
 - Installation effect transposition from FTD CROR to CROR A/C based on WTT results
- **Special skills, capabilities**

See compilation at the end of the present Topic description

- **Major deliverables and schedule (estimate)**

<i>Deliverables</i>			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
ST-1a – A_D1.1-1	Core-Partner(s) contribution detailed description (content, deliverables , planning)	Report	April 2015
ST-1a – A_D1.1-2	Contribution to CROR FTD concept freeze review	Data, Report	Nov 2016
ST-1a – A_D1.1-3	Contribution to CROR FTD preliminary design review (PDR)	Data, Report	Nov 2017
ST-1a – A_D1.1-4	Contribution to CROR FTD conceptual design review (CDR)	Data, Report	2018
ST 1a – A_D1.1-5	Contribution to CROR FTD test readiness review (TRR)	Data, Report	2019
ST 1a – A_D1.1-6	Contribution to CROR FTD data release & pre-analysis	Data, Report	2021

b) Module B

Pre- and post-flight aero acoustic characterization of a full scale integrated CROR propulsion system

Linked to:

LPA WP1.1 CROR demo- engine FTD – “In Flight CROR demonstration”

- **Short description**

The CROR propulsion technology is the key contributor to the overall aircraft package that can offer an improvement in fuel burn efficiency in the order of 15% - 20% compared to the best today's technology status. With best performance at cruise speed of Ma0.72 to Ma0.76, a huge amount of joint R&T activities to develop and integrate the CROR engine concept for short and medium haul large transport aircraft have been launched in Clean Sky since July 2008.

Despite significant progress to develop and mature the CROR propulsion technology made in previous research programs addressing the issues of certification, cabin and community noise, as well as various aspects of the propulsion system integration and the engine design, a major flight test

campaign with a full sized flight-worthy engine is still THE yet missing key contribution to be able to accomplish the the very ambitious overall programme target to for TRL 6.

The scope of this Module is prepare, conduct and analyze “Pre-flight” experiments and numerical studies and to support the large scale flight demonstration and to cooperate in the processing and analysis of the in-flight demonstration data with the CROR demo- engine.

The major objectives of this Module are to:

- Provide substantial contribution and orientation in experiments and numerical studies on the aerodynamic efficiency versus noise level for a full size integrated CROR pusher engine in scaled experiments and under operational conditions including interaction with pylon wake
- Contribute to experimentally validate a pylon concept and system integration in scaled and full size tests, in particular addressing loads, vibration, and noise attenuation technologies in real size
- Contribute to demonstrate and validate the selected propeller and blade design
- Provide, process and analyse the data emerging from Clean Sky experiments and numerical studies and synthesize the results with ground tests and CROR demo-engine flight test data in LPA WP1.1. Re-calibrate tools analysis and converge results to accomplish TRL 6
- Provide coherent contribution to demonstrate and validate the viability of assumptions for the chosen engine concept like power gearbox, blades, pitch control, lubrication system, energy and thermal management, engine control concept. The domains that will be analysed for engine benefits are dynamic and mechanical behaviour, operability and transients over the whole flight profile, vibrations, blade noise characteristics at aircraft scale with installation effects, etc.



Figure 3. Full size CROR demo engine Flight Test Demonstration onboard the Airbus A340-300 R&T test bed

The activity is aiming at provide a substantial contribution to the investigation, analysis and understanding of acoustic and aerodynamic features and effects when installing CROR engines to an aircraft. Starting with the engine design and integration concept adopted from CleanSky, the research work shall provide data and information for an improved design for a future concept.

The applicant(s) shall deal with two main areas of work, namely to contribute to research to be conducted with scaled CROR engines at low and high speed in Wind Tunnel tests, and, with the background of these tests the contribution to the preparation, conduct and analysis of flight tests.

The successful applicant(s) shall coordinate closely with Airbus, the engine manufacturers contributing to the specific tests and the Core-Partner(s) that will be selected for another topic, which contains strategic activities in the same LPA work package, but with stronger focus to the flight test activities and related instrumentation.

A list of activities has been already identified as described below. This, yet not exhaustive list, will be complemented during the execution of the programme in the light of achievements and progresses. In the proposal the core-partner candidate shall demonstrate how he will tackle the listed activities together with additionally proposed activities that are deemed potentially relevant in this context. The benefits and the contribution to the overall objectivities shall be given.

Applicant(s) shall take also responsibility for work package lead (incl. co-developing the project management plan and closely monitoring the project progress) which in detail has to be defined in the negotiation phase.

Development of experimental equipment and instrumentation

- Development of advanced measurement equipment and data acquisition systems
- Improvement, calibration, adaptation of existing instrumentation and equipment
- Contribution / coordination of preparatory work, reference measurements, etc.

It is anticipated that for the test methodology there will be significant commonality between the instrumentation, data acquisition systems, advanced measurement techniques (specifically acoustic) and test technologies that are developed for both low and high speed applications and for the experiment campaigns at different scale, respectively in the different test facilities

CROR specific topics

Large scale (1/5) CROR High Speed characterisation in installed condition in large Wind Tunnel (expected Q3/ 2017):

- It is assumed that the wind tunnel test itself (including all activities related to the test preparation, model commissioning, wind tunnel shakedown and de-rigging) will be performed through a Call-for-Tender.
- Core-Partner(s) Model Hardware / all model mounting hardware, Strain Gauge Balance telemetry

systems RSB's & Software

- Specific Test Equipment High Fidelity Acoustic test measurement & methodology
- development and flow visualization

Full CROR powered Aircraft 1/10th scale aerodynamic test in large Wind Tunnel (expected Q4/2018):

- It is assumed that the wind tunnel test itself (including all activities related to the test preparation, model commissioning, wind tunnel shakedown and de-rigging) will be performed through a specific Call-for-Tender.
- Core-Partner(s) all model mounting hardware, telemetry systems RSB's & Software
- Specific Test Equipment High Fidelity Acoustic test measurement & methodology development

Full CROR powered Aircraft 1/10th scale acoustic test in large Acoustic Wind Tunnel (expected Q4/2019):

- It is assumed that the wind tunnel test itself (including all activities related to the test preparation, model commissioning, wind tunnel shakedown and de-rigging) will be performed through a Call-for-Tender.
- Core-Partner(s) all model mounting hardware, telemetry systems RSB's & Software
- Specific Test Equipment High Fidelity Acoustic test measurement & methodology development & Design, manufacture, installation and commission of an Acoustic Tunnel liner suitable for model configuration and test envelope.

Contribution in experimental and numerical reasearch – Aerodynamics

- Flowfield effect: Assess propeller robustness to inflow disturbances – Measurement techniques in the volume setup development
- Installation effect transposition from FTD CROR to CROR A/C through WTT and numerical methods
- Blade deformation computation and evaluation – Instrumentation setup development
- Transition prediction evaluation - Instrumentation setup development
- 1P loads and moments prediction
- Characterisation of vibration source
- Characterization of vibrations for operational flight: definition and set-up instrumentation and analysis
- Characterization of vibrations for non-classical configuration
 - inflow impact: wing wake, spoiler deflection, high alpha & high sideslip effect
 - Toe & Tilt effect
 - high angle of attack with flow separation on the wing
 - Effect of spoiler deployment and high sideslip

- Characterize the slipstream effect on rear end: HTP and VTP buffeting
- Characterize vibrations without wind
- assess ground vibration
- Specific tests on ground to qualify vibrations without wind
- Characterisation of the flutter A/C and whirl flutter (propeller effect)

Contribution in experimental and numerical reasearch – Acoustics

Instrumentation for Flight Test Demonstration

- CFD/CAA simulation of FTD & baseline CROR aircraft
 - Installation effect transposition from FTD CROR to CROR A/C through WTT
- On ground instrumentation for flyover tests
 - FTB CROR specific on ground instrumentation development
 - Static CROR
 - CROR Ground Test Demonstrator (GTD) specific instrumentation (array definition and post treatment)
- Flight Test demonstration
 - CROR demo engine flight test demonstration specific aircraft acoustic instrumentation development (source separation though array processing, NFN-interior noise transfer function...)
- En Route Noise (ERN), operational noise (noise on ground)
 - Numerical simulations of ERN, and operational noise (source, propagation, annoyance)
- FTD CROR
 - Installation effect transposition from FTD CROR to CROR A/C through numerical methods
- **Special skills, capabilities**

See compilation at the end of the present Topic description

- **Major deliverables and schedule (estimate)**

<i>Deliverables</i>			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
ST-2a – B_D1.1-1	Core-Partner(s) contribution detailed description (content, deliverables , planning)	Report	Oct 2015
ST-2a – B_D1.1-2	Contribution to CROR FTD concept freeze review	Data, Report	2016
ST-2a – B_D1.1-3	Contribution to CROR FTD preliminary design review (PDR)	Data Report	2017
ST-2a – B_D1.1-4	Contribution to CROR FTD conceptual design review (CDR)	Data Report	2018
ST-2a – B_D1.1-5	Contribution to CROR FTD test readiness review (TRR)	Data Report	2019
ST-2a – B_D1.1-6	Contribution to CROR FTD data release & pre-analysis	Data Report	2021

c) Module C

Testing and validation of the dynamic and impact behavior of an advanced fuselage rear end

Linked to:

LPA WP1.2 Advanced engine integration driven fuselage - CFRP Rear End Large Scale Demonstration of Rear Fuselage mounted Engine Configuration -

- **Short description**

New, eco-efficient aircrafts are challenged by a demand to significantly reduce the CO₂ and NO_x emission. To achieve these goals, Airbus is exploring new configurations for integrating advanced engines and propulsion concepts to the aircraft. Most of such promising concepts as the CROR-engine, Boundary Ingestion Layer (BIL), Ultra High Bypass Ratio engines (UHBR), multiple fan cannot be integrated simply by replacing engines of the current generation, but require a substantial change of the principle aircraft configuration.

Results from recent research programmes have provided much evidence that many of these concepts do lead to better gains of ecologic and economic efficiency by installing them on the rear end of the fuselage.

The advantage of an installation on the rear fuselage is motivated by the favourable spatial integration conditions in particular for large fan or rotor diameters or multiple fans which can be the key for achieving unprecedented fuel efficiencies. In case of un-ducted engine architecture as the CROR, the rearward shift of the engines away from the wing provides additional advantages in cabin noise and passenger comfort and safety improvement.

This Module is aiming at providing substantial contribution to the mechanical characterization of aircraft composite rear end for rear mounted engine aircraft configurations. A key objective is the structural characterization of the rear fuselage (static & fatigue, impact, vibro-acoustics).

As already mentioned above, the powerplant Integration activities in IADP-LPA, Platform 1 are generally aiming at identifying and developing innovative integration solutions for both, future large by-pass ratio turbofan engines and contra rotating open rotor engines.

The scope of powerplant integration activities within the Large Passenger Aircraft is the maturation of solutions up including flight testing or ground testing of key enablers for future application. Also, in parallel to the technologies, the scope of activity contains also the development of capabilities to enable those demonstrations in the most efficient manner.

With particular respect to the “Dynamically Efficient Fuselage & Technologies”:

- CROR engine integration will significantly affect the spectrum of dynamic forces and loads to be transferred, carried and damped in the primary structure of the fuselage and transferred to the cabin. Research related to the associated design and functional solutions is part of the module.
- Structural fatigue shall be investigated and solutions for an a dedicated design but also material solutions shall be developed and proposed
- Associated to the rear end design to be developed, a suitable vibration attenuation system shall be developed in close coordinated with activities dealing with the attenuation of the acoustic signature in the cabin.

The applicant(s) shall provide a proposal how to deal with the subjects listed in the following, yet not exhaustive table of activities. He may provide evidence of his experience in the understanding of structural (i.e. fuselage) response characteristics exposed to dynamical mechanical and acoustical loads. It is intended to assign the successful applicant(s) a coordinating or leading role within work package, details to be defined in the negotiation phase.

Testing and validation of the dynamic and aeroelasticity behaviour of the CROR rear end

Substantial contribution in the conduct and coordination in

- rear end subcomponent full representative tests to validate the dynamic behaviour and blade imbalance behaviour after blade release, as support for one or more of the following activities: bench manufacturing and test set up, test, simulation, instrumentation and analysis including the test data reduction. Results from this test will allow partial or full validation of safety levels regarding opposite engine continued operation, structure vibration strength, and aircraft pilotability.
- fatigue testing of rear end structures exposed to high vibration loads from rear mounted engines; Provide material data to enable the safe design of structures with high vibratory loading caused by CROR engines. Develop improved materials.
- development, demonstration, validation and manufacturing of innovative fuselage, pylon and interface concepts addressing loads, vibration /noise attenuation technologies and robustness of the design.
- rear end (T-tail and pylon) aero-elastic and flutter analysis and optimization by simulations and partial tests.
- composite-composite impact structural design and testing with respect to test set-up definition and supply, pre-test simulations through high velocity impact assessment. For the experiments, the applicant(s) shall contribute to the preparation of the test rig and bench, the required definition and supply of instrumentation, calibration activities, test conduct, data processing post processing and analysis of results

Fuselage shielding

Contribution to the development of robust add-on concepts with respect to high and low energy impact on Rear End as well as development and demonstration of concepts for shielding health monitoring (SHM).

▪ **Special skills, capabilities**

See compilation at the end of the present Topic description

- **Major deliverables and schedule (estimate)**

<i>Deliverables</i>			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
ST-2a – C_D1.2-1	Core-Partner(s) contribution detailed description (content, deliverables , planning)	Report	Oct 2015
ST-2a – C_D1.2-2	Contribution to fuselage shielding	Contribution Report	2017
ST-2a – C_D1.2-3	Contribution to dynamic and aeroelastic behaviour validation and test	Report & test data results	2019
ST-2a – C_D1.2-4	Contribution to CROR composite-composite impact	Report & test data results	2019

d) Module D

Vibro-acoustic characterisation and structural impact

linked to:

LPA WP1.2 Advanced engine integration driven fuselage

- CFRP Rear End Large Scale Demonstration of Rear Fuselage mounted Engine Configuration -

- **Short description**

New, eco-efficient aircrafts are challenged by a demand to significantly reduce the CO₂ and NO_x emission. To achieve these goals, Airbus is exploring new configurations for integrating advanced engines and propulsion concepts to the aircraft. Most of such promising concepts as the CROR-engine, Boundary Ingestion Layer (BIL), Ultra High Bypass Ratio engines (UHBR), multiple fan cannot be integrated simply by replacing engines of the current generation, but require a substantial change of the principle aircraft configuration.

Results from recent research programmes have provided much evidence that many of these concepts do lead to better gains of ecologic and economic efficiency by installing them on the rear end of the fuselage.

The advantage of an installation on the rear fuselage is motivated by the favourable spatial integration conditions in particular for large fan or rotor diameters or multiple fans which can be the

key for achieving unprecedented fuel efficiencies. In case of un-ducted engine architecture as the CROR, the rearward shift of the engines away from the wing provides additional advantages in cabin noise and passenger comfort and safety improvement.

The scope of this Module is related to activities supporting the ground demonstration of a CROR Aircraft rear end (rear fuselage, tails, pylon, engine simulators).

With particular respect to the “Acoustically Efficient Fuselage & Technologies” the main research contributions proposed by the Core-Partner(s) shall be driven by following aspects:

- CROR engine integration will significantly affect the interior noise of a passenger aircraft in noise as well as vibration comfort due to high excitation levels impinging fuselage surface.
- The directivity of CROR noise pattern is even detrimental to noise comfort when placing at rear end as pressure fluctuations excite the fuselage structure to vibrate which then is been transmitted towards cabin - beside direct sound incidence at cabin area. Both effects are at different frequency ranges in such that different control principles are to be applied for different regions.
- Thus to enable an effectively design and tailoring of noise and vibration control means a precise understanding of the fuselage response characteristics is a prerequisite.

The applicant(s) shall submit a proposal how to provide substantial contribution to the following, yet not exhaustive, list activities and research subjects to the CROR rear end development. The aim is also to assign the successful applicant(s) a coordinating or leading role within work package, details to be defined in the negotiation phase.

Composite-composite impact

Contribution to the partial test of high and low energy debris into rear end, as for example support for one or more of the following steps:

- Test set-up definition & supply
- Pre-test simulations through high velocity impact assessment
- Test Rig and bench
- Instrumentation definition & supply
- Impact testing contribution
- Data processing
- Post-test simulations & experimental calibration through high velocity impact assessment contribution

Fuselage shielding

Contribution to the development of robust add-on concepts with respect to high and low energy

impact on rear end as well as development and demonstration of concepts for shielding health monitoring (SHM).

Other Rear end components and interfaces contribution opportunities

Contribution to fatigue test of rear end structures exposed to high vibration loads from rear mounted engines; Provide material data to enable the safe design of structures with high vibratory loading caused by CROR engines Develop improved materials,

Contribution to demonstration and validation of innovative fuselage and pylon and interface concepts addressing loads, vibration/noise attenuation technology and robust design.

Contribution to rear end (T-tail and pylon) aeroelastic and flutter analysis and optimization by simulations.

Acoustic efficient fuselage & technologies

The scope of this activity is to characterize the structure-dynamical and vibro-acoustical behavior and dominant features of a real rear end fuselage structure as well as the vibration propagation towards cabin area at maturity level of TRL5+. The structure will be excited by artificial loads and a close-to-reality CROR near field noise excitation determined in WP 1.1 as well as based on numerical simulations validated by in-flight tests.

A second goal is to analyze, evaluate and validate the coupling of the near field noise to the structure. Moreover the energy acceptance of the fuselage structure will be tested enabling determining key parameters (phase pattern, wave number/ length) for the design of a structure-integrated noise and vibration control architectures and means.

A further objective is to develop a method for the determination of engine vibration related noise and vibration propagation (>50Hz). As in the previous work package the focus was on the noise and vibration induced by the pressure fluctuations from the CROR, this work package addresses the noise with is caused by engine vibration propagating via pylon and engine attachments throughout fuselage into the cabin (e.g. compressor stage, N1, ...).

▪ **Special skills, capabilities**

See compilation at the end of the present Topic description

- Major deliverables and schedule (estimate)

<i>Deliverables</i>			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
ST-1a - D_D1.2-1	Core-Partner(s) contribution detailed description (content, deliverables , planning)	Report	April 2015
ST-1a - D_D1.2-2	Contribution to CROR Composite-composite impact	Report & test data results	2019
ST-1a – D_D1.2-3	Contribution to fuselage shielding	Contribution Report	2017
ST1a – D_D1.2-4	Contribution to Other Rear end components and interfaces contribution opportunities	Contribution Report	2018
ST1a – D_D1.2-5	Characterisation of the structure-dynamical and vibro-acoustical behaviour and its dominant features of a real rear end fuselage structure	Report & Data	2023
ST1a – D_D1.2-6	Evaluation and validation of the coupling of near field noise into a real rear end fuselage structure	Report & Data	2023
ST1a – D_D1.2-7	Method for the determination of engine vibration related noise in and vibration propagation towards passenger cabin (>50Hz)	Report & Data	2018

e) Module E

Aero-acoustic measurements and characterization

linked to:

LPA WP1.6 Demonstration of Radical Aircraft Configurations

- Turbofan FTD – Next Generation Large Engine Demonstration -

▪ Short description

The intention of this Module related to work package 1.6 is the flight demonstration of a new aircraft configuration comprising a flying test bed with a fully integrated UHBR engine.

A key challenge of the integration of an UHBR to the aircraft is to retain positive performance gains of the isolated engine against the penalties of integration effects.

The overall objective of this module is to support the initial definition and subsequent development of a design strategy which provides the perfect synthesis between the airframe and the advanced engine with its associated new technologies with respect to the aero-acoustic integration effects. A close collaboration between Airbus, Core-Partner(s) and engine manufacturer is key. It is intended that a coordinating role in the work programme shall be assigned to the successful applicant(s) related to the research area of aeroacoustic, e.g. through the lead of a corresponding work package.

The scope of this module is about the characterisation of the aero-acoustic integration effects of UHBR engines to future large passenger aircraft, to measure analyse the aeroacoustic performance and to contribute to the research and development of alternate solutions.

A close collaboration between Airbus, Core-Partner(s) and engine manufacturer is key. It is intended that a coordinating role in the work programme shall be assigned to the successful applicant(s) related to the research area of aeroacoustic, e.g. through the lead of a corresponding work package.

The proposing candidate shall provide a vision how to contribute to the following main elements of research:

- Support of integration work for UHBR propulsion systems on architectural level
- Multi-disciplinary optimisation approach for wing / pod-pylon interface
- Support on definition of suitable component demonstrators for the technology

Explicit contributions are expected to the following subjects of research and development. The applicant shall provide a short proposal how to provide added value and potential solutions to the individual subjects

Aerodynamics

- In-flight flow visualization and measurements instrumentation development
- Fan/airframe integration computations
- Computation and test of active and passive flow control for aggressive powerplant integration

Acoustics: UHBR Future Challenge on fan noise

The applicant(s) is (are) expected to bring significant contributions in the characterization, the understanding and potentially solutions with regards to the following problematics:

Fan Noise

- Shorter inlet (L/D aerolines -> 0,6 to 0,4!) and bypass duct : Reduction of treated area and associated increase of noise
- Shorter inlet (+ flow incidence) : inlet flow distortion noise and/or less cut-off efficiency on steady loading noise
- GTF Engine: Lower regime and shift of the global spectrum to lower frequencies, more difficult to attenuate with classical liners, taking into account integration constraints (IFS, trailing edge of OFS, potentially VAN). Possible BSN in cruise.
- Reduction of Fan-OGV space, low count OGV : increase of Rwd fan noise (and Fwd fan noise). Cut-off -> cut-on design : strong increase of 1BPF

Jet Noise

- Increased close-coupling between engine and wing during take-off and approach introduces a risk on high jet-wing interaction noise. It poses a challenge on predicting and reducing the total installed jet noise.
 - New architectures of bypass nozzle and pylons could potentially modify the installed jet noise.
- **Special skills, capabilities**

See compilation at the end of the present Topic description

- **Major deliverables and schedule (estimate)**

In the course of detail planning, it generally has to be expected that there have to be considered intermediate steps (e.g. document drafts for review) in addition to the below-mentioned deliverables.

<i>Deliverables</i>			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
ST-1a – E_D1.6-1	Core-Partner(s) contribution detailed description (content, deliverables , planning)	Report	April 2015
ST-1a – E_D1.6-2	Contribution to Large Turbofan FTD concept freeze review	Data, Report	June 2015
ST-1a – E_D1.6-3	Contribution to Large Turbofan FTD preliminary design review (PDR)	Data Report	Jan 2016
ST-1a – E_D1.6-4	Contribution to Large Turbofan FTD conceptual design review (CDR)	Data Report	Jan 2017
ST-1a – E_D1.6-5	Contribution to Large Turbofan FTD test readiness review (TRR)	Data Report	Jan 2018
ST-1a – E_D1.6-6	Contribution to Large Turbofan FTD data release & pre-analysis	Data Report	Nov 2020

f) Module F

Pre-and post-flight aero-acoustic characterization

Linked to:

LPA WP1.6 Demonstration of Radical Aircraft Configurations

- Turbofan FTD – “Next Generation Large Engine Demonstration”

▪ **Short description**

This contribution is aiming at supporting the in flight demonstration of next generation turbofan engine together with the associated nacelle and aircraft integration technologies. The scope includes aerodynamic and acoustic characterization with specific emphasis on the instrumentation development and supporting intake and nozzle wind tunnel tests. A close collaboration between Airbus, Core-Partner(s) and engine manufacturer is key.

▪ **Scope of work:**

General

- Support of integration work for UHBR propulsion systems on architectural level
- Multi-disciplinary optimisation approach for wing / pod-pylon interface
- Support on definition of suitable demonstrators for the technology

UHBR Specific Topics

UHBR Nozzle test in Nozzle Bench (expected September 2017):

The aim of this activity will be the characterisation of the nozzle aerodynamic coefficient, acoustic response and compatibility with the Engine, taking into account the specificities of large by-pass ratio and potential variable area nozzle for the by-pass duct.

- Test feasibility study in accordance with model specification. Identification of required test and instrumentation hard and software development.
- Definition and development up to proof testing of those new test and instrumentation hard and softwares.
- It is assumed that the wind tunnel test itself (including all activities related to the test preparation, model commissioning, wind tunnel shakedown and de-rigging) will be performed through a Call-for-Tender.

UHBR Intake Reynolds effect test in pressurized low speed wind tunnel (expected June 2017):

The focus of this activity will be the characterisation of short air intake to fan compatibility with the

Engine, taking into account the specificities of large by-pass ratio for low speed (cross wind and high angle of attack) conditions. Also, acoustic effects to support community noise evaluation will be investigated.

- Test feasibility study in accordance with model specification. Identification of required test and instrumentation hard and software development.
- Definition and development up to proof testing of those new test and instrumentation hard and softwares.
- It is assumed that the wind tunnel test itself (including all activities related to the test preparation, model commissioning, wind tunnel shakedown and de-rigging) will be performed through a Call-for-Tender.

Development of experimental equipment and instrumentation

It is anticipated that for the test methodology there will be significant commonality between the instrumentation, data acquisition systems, advanced measurement techniques (specifically acoustic) and test technologies that are developed for both low and high speed applications.

Acoustic:

- **Instrumentation for acoustic characterization of uninstalled and installed UHBR engines in wind tunnel and fly over tests**
- **On ground instrumentation for flyover tests**
FTB UHBR specific on ground instrumentation development
- **Static UHBR test**
UHBR static test specific instrumentation (array definition and post treatment)
- **Flight test demonstration**
FTD UHBR specific aircraft acoustic instrumentation development (source separation through array processing, NFN-interior noise transfer function...)

Aerodynamics

- Computation and test of active and passive flow control for aggressive powerplant integration
- In-flight flow visualization and measurements instrumentation development
- Fan/airframe integration computations

▪ **Special skills, capabilities**

See compilation at the end of the present Topic description

- **Major deliverables and schedule (estimate)**

<i>Deliverables</i>			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
ST-2a – F_D1.6-1	Core-Partner(s) contribution detailed description (content, deliverables , planning)	Report	April 2015
ST-2a – F_D1.6-2	Contribution to Large Turbofan FTD concept freeze review	Data, Report	June 2015
ST-2a – F_D1.6-3	Contribution to Large Turbofan FTD preliminary design review (PDR)	Data Report	2016
ST-2a – F_D1.6-4	Contribution to Large Turbofan FTD conceptual design review (CDR)	Data Report	2017
ST-2a – F_D1.6-5	UHBR Nozzle Test data	Data Report	2017
ST-2a – F_D1.6-6	UHBR Reynolds Effect test data	Data Report	2017
ST-2a – F_D1.6-7	Contribution to Large Turbofan FTD test readiness review (TRR)	Data Report	2018
ST-2a – F_D1.6-8	Contribution to Large Turbofan FTD data release & pre-analysis	Data Report	2020

g) Module G

Design and Analysis of a Novel Propulsion Architecture, “Competitive Concept Design”

linked to:

WP1.6 Demonstration of Radical Aircraft Configurations

- Aircraft Configuration Development for Alternative Propulsion Concepts -

- **Short description**

The intention of this Module related to LPA work package 1.6. is to develop advanced aircraft concepts based upon a design strategy targeting a perfect synthesis between innovative airframe concepts and a novel propulsion architecture (e.g. hybrid propulsion) and its comprising individual technologies. The plan is to open a new design and validation space and offer through this approach a set of efficiently developed (time, cost) and validated airframe and propulsion concepts to

overcome the threshold to full game-changing aircraft design.

To fulfill the intention of work package 1.6, a very high integration level between airframe and propulsion system is required. This results in a higher effort on the integration side. In addition, technologies developed in other parts of Clean Sky 2 are to be integrated where beneficial.

With a focus on the propulsion integration concepts *beyond* the UHBR and the CROR, the activities in this work package shall lead to a gate decision for further research and activities including demonstrators of selected novel propulsion concepts by the end of 2018. The overall aircraft architecture will be a result of the opened design space, i.e. of the hybrid propulsion architecture. The optimal hybrid propulsion architecture with respect to flight mission profiles, based on synergies and opportunities, has to be defined. An investigation of the interactions and limitations of radical aircraft configurations and of projected hybrid energy technologies shall lead to a sound concept.

For the configuration development an approach with three different, competitive design teams against common requirements is sought, to explore the complete design space. The design teams should interact on a regular basis, and one or several concepts for further down-selection should be the result of this work.

The scope of activities in this module is related to LPA work package 1.6 and encompasses the exploration of the potential of fully integrated hybrid propulsion systems with the airframe. This goes beyond the powerplant integration activities for both, future large by-pass ratio turbofan engines and contra rotating open rotor engines, performed in the work packages 1.1, 1.2, 1.6.

The intention is that the selected Core-Partner(s) will take a leading role to coordinate Partner activities, presumably through a lead of an associated work package. The details will be defined in the negotiation phase. Compared to the expected Core-Partner(s) contribution to the other Modules, the targeted technology goes even more beyond the state-of-the-art. In the proposal the applicant(s) shall provide a vision of how the following key objectives in this module shall be addressed:

- Definition of common baseline
- Integration of available technology bricks
- Development of different concepts for further down-selection
- Specify how the concepts can be demonstrated

- **Special skills, capabilities**

See compilation at the end of the Strategic Topic description

- **Major deliverables and schedule (estimate)**

<i>Deliverables</i>			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
ST-1a – G_D1.6.1-1	Baseline for Envisaged Alternative Propulsion Aircraft Configurations	Document	t0+3
ST-1a – G_D1.6.1-3	Concept Analysis of Alternative Propulsion Aircraft Configuration 1	Document	t0+18

3. Skills and capabilities

- **General**

- Applicant(s) shall have a strong background and experience in overall aircraft design and the related field of flight physics.
- Applicant(s) shall provide evidence of a sound technical knowledge in the field of proposed contributions, he shall be able to demonstrate that this knowledge is widely recognized.
- Applicant(s) shall provide evidence of strong experience in project management in “time, cost and quality” together with evidence of substantial contribution in large research and development projects in the associated area.
- Applicant(s) is (are) expected to take also responsibility for work package lead (incl. co-developing the project management plan and closely monitoring the project progress) which in detail has to be defined in the negotiation phase.

- **Related to Module A**

- Profound background in aerodynamics relevant for large transport aircraft research
- Shape and component design using CATIA v5
- High-fidelity aerodynamic CFD modelling skills using hybrid approach, from simplified to unsteady methods
- Skills related to engineering and research in aero-elasticity (fluid-structure coupling approach integrated force/displacement/mesh deformation approaches) and adapted to CROR blades specificities: rotation, high twist, limited aspect ratio
- Strong experience in the development and application of acoustic measurement techniques and acoustic data analysis (near- and far field)
- State-of-the-art numerical methods for acoustic source location, noise propagation and noise

evaluation

- The applicant(s) shall have access to the following test means:
 - P1: The applicant(s) shall have access to a large single aisle flight test aircraft whereas an Airbus type of aircraft is preferred.
 - P2: Access to a chase-aircraft

▪ Related to Module B

- Profound background in aerodynamic research relevant for large transport aircraft research
- Aerodynamic CFD modelling skills using structured multiblock approach, from simplified to unsteady methods
- Skills related to engineering and research Aero elasticity skills (fluid-structure coupling approach integrated force/displacement/mesh deformation approaches) and adapted to CROR blades specificities: rotation, high twist, limited aspect ratio
- Laminar flow technology
- Flow control simulations
- Shape and component design using CATIA v5
- High-fidelity aerodynamic CFD modelling skills using hybrid approach, from simplified to unsteady methods
- Aero elasticity skills (fluid-structure coupling approach integrated force/displacement/mesh deformation approaches) and adapted to CROR blades specificities: rotation, high twist, limited aspect ratio
- Development and application of acoustic measurement techniques and acoustic data analysis (near- and far field)
- Numerical methods for acoustic source location, noise propagation and noise evaluation

For research in aero-acoustics

- JeCaline array localization code, for use and development

▪ Related to Module C

- Extensive experience in aero-elasticity and flutter analysis, simulation and correlation by test.
- Sound experience in high energy impact skills both from experimental and numerical standpoint.
- Extensive experience in demonstration and validation of innovative engine, pylon and fuselage interface concepts addressing loads, vibration/noise attenuation technology and robust design including fatigue and high vibration loads assessment.

▪ Related to Module D

CROR rear end

- Extensive experience in high energy impact skills both from experimental and numerical stand-point
- Extensive experience in Aero elasticity and flutter analysis, simulation and correlation by test.
- Extensive experience in demonstration and validation of innovative engine, pylon and fuselage interface concepts addressing loads, vibration/noise attenuation technology and robust design including fatigue and high vibration loads assessment.

Acoustic efficient fuselage & technologies

- Extensive experience and capabilities on multi-channel structure-dynamical and vibro-acoustics testing of large / full scale aircraft fuselage structures (>400 channels, >2500 test positions) with multi-source excitation (parallel), data reduction, checking, problem resolving.
- Test methods and analysis tools for phase correct (+/- x% tolerance) structure-dynamical and vibro-acoustics characterisation at deterministic, multi-tone excitation at frequency range between 80Hz and 250Hz.
- Deep understanding of energy coupling in structures.
- Exceptional expertise in vibration testing and analysis at 40Hz to 100Hz at large / full scale demonstrators or air aircraft (e.g. ground vibration testing and problem solving).

▪ **Related to Module E**

- Aerodynamic CFD modelling skills using structured multiblock approach, from simplified to unsteady methods
- Aeroelasticity skills (fluid-structure coupling approach integrated force/displacement/mesh deformation approaches) and adapted to CROR blades specificities: rotation, high twist, limited aspect ratio
- Laminar flow technology
- Flow control simulations

▪ **Related to Module F**

- Aerodynamic CFD modelling skills using structured multiblock approach, from simplified to unsteady methods
- Aeroelasticity skills (fluid-structure coupling approach integrated force/displacement/mesh deformation approaches) and adapted to CROR blades specificities: rotation, high twist, limited aspect ratio
- Laminar flow technology
- Flow control simulations

For research in aero-acoustics

- Array localization code, for use and development

■ Related to Module G

- Capabilities and experience in overall aircraft design for large transport aircraft
- Resources with senior expertise in aircraft conceptual design,
- Access and strong experience in using state-of-the-art aircraft design and performance tools
- Experience in European collaborative Research with partners from academia and industry

4. Abbreviations

AFC:	Active Flow Control
BANOERAC	Background Noise Levels and Noise Levels from en route aircraft
BIL	Boundary Ingestion Layer
BR:	Bypass Ratio
BSN:	Buzz Saw Noise
CAA	Computational Aeroacoustics
CBM:	Condition Based Maintenance
CFD:	Computational Fluid Dynamics
CfP	Call for Proposal
CP	Call for Partner(s)
CROR:	Counter Rotating Open Rotor
CS2:	Clean Sky 2
CS2JU:	Clean Sky 2 Joint Undertaking
ERN	En route noise
E2E:	End To End
FP7 L2:	7th European Framework Programme - Level 2 project
FTD	Flight Test Demonstrator
GTF	Geared Turbo Fan
HLFC:	Hybrid-Laminar Flow Control
HTP	Horizontal Tail Plane
IHMM:	Integrated Health Monitoring and Management
LPA	Large Passenger Aircraft
OGV:	Outlet Guide Vane
PMT:	Processes Methods and Tools
SHM:	Structure Health Monitoring
TBL	Turbulent Boundary Layer
TRL:	Technology Readiness Level
UHBR	Ultra High Bypass Ratio
VTP	Vertical Tail Plane
WBS	Work Breakdown Structure
WTT	Wind Tunnel Test



Topics for Core-Partners Call 1



II. Integrated Flow Control Applied to Large Civil Aircraft

Leader and Programme Area [SPD]	LPA		
Work Package (to which it refers in the JTP)	WP 1.4		
Indicative Topic Funding Value	4 M€		
Leading Company	Airbus		
Duration of the action	9 years	Start Date	1 st April 2015
Date of Issue	5 th of June 2014	Call Wave	1

Topic Number	Title		
JTI-CS2-2014-CPW01-LPA-01-02	Integrated Flow Control Applied to Large Civil Aircraft	Duration	9 years
	<i>Advanced HLFC Fin Aerodynamic Design Work</i>	Start Date	1 st April 2015

The purpose of the present Topic Description is to find a Core-Partner(s) who contributes on a strategic and architecture level with his capabilities, skills and resources to perform highly integrated and multi-disciplinary aerodynamic design for a fin equipped with HLFC (Hybrid Laminar Flow Technology) technology. The associated work to be performed is targeting to achieve a high Technology Readiness Level (pre-serial standard) for this technology.

The principle of operation requires a high experience in working in a multidisciplinary and integrated design environment. The expected high number of contributing parties coming from all over Europe and the complexity of the development work require also from the Core-Partner(s) personnel to become an essential management element in the organisation of the project management plan. This implies also the readiness to take responsibility in the technical lead of action, through leading work packages or sub work packages, and the definition and issuing of Call for Proposal partners.

It is expected that the Core-Partner(s)' commitment to this Topic includes the distinct readiness along the program lifetime to be ready to follow possible necessary technical program changes/adaptions within the given technical scope.

Within the given budget volume the candidate shall also show readiness to contribute to the design of advanced flow control technology applied on wing/pylon area provided that program decisions justify at any time an update of the objectives.

1. Background

The activities of this topic cover the aerodynamic design work for the advanced HLFC fin linked to the WP1.4 “Hybrid Laminar Flow Control Large Scale Demonstration” in IADP-LPA, Platform 1, s. Figure 1. The scope, described work content, objectives and the mentioned work packages (incl. nomenclature) fully refer to the Joint Technical Proposal (JTP), version 4, as the baseline document.

The activities described in the document at hand are in strong interrelation with the LPA Topic 3 which covers the corresponding structural design work and the manufacturing of the advanced HLFC fin.

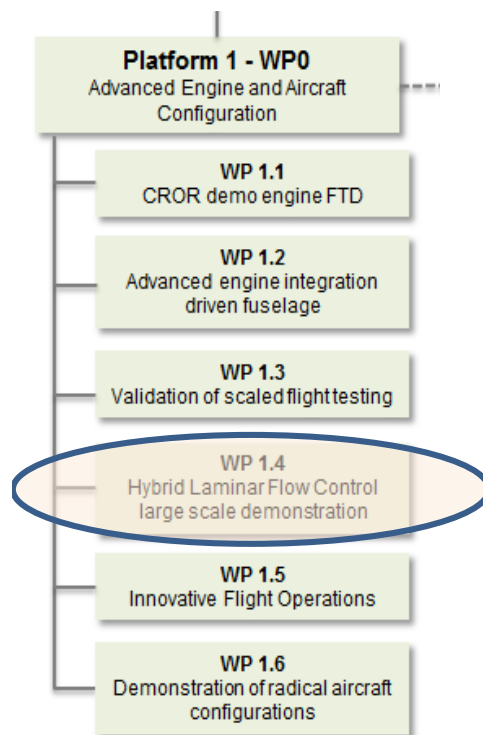


Figure 1. Part of the Work Breakdown Structure relevant for this Strategic Topic

The significant drag reduction potential of the HLFC technology was addressed in a number of large R&T programmes in the US and in Europe for more than two decades ago. In 2011 Boeing revealed flight test pictures with a HLFC system applied on the fin of the B787-8 and also advertising this HLFC system as aerodynamic enhancement package for the B787 evolution. Despite this pre-serial example by Boeing and even though the physics and the technical principles are well understood, no “industrial” technology solution could be developed so far to materialize the aerodynamic potential, while keeping the complexity and weight of the required systems low.

Furthermore, the effort and cost to manufacture, operate and maintain these systems need to be brought down to an acceptable level. Boosted by the recent progress to mature the NLF technology

for short range large transport aircraft, there is a significant transfer of knowledge and technologies applicable for the HLFC technology. In addition, a set of new technologies in virtually all areas of material processing, manufacturing and automation in combination with new materials open the door to develop industrially viable solutions for the HLFC technology applied on airframe.

Based on the results of the FP7 L2 Project "AFLoNext", in which the development and the first operational experience with advanced HLFC technology will be acquired, the scope in Clean Sky 2 is to collect long-term operational experience with this technology applied on the fin including issues of airworthiness, respectively certification related issues. Further gravity lies on the development of the full manufacturing chain according to industrial pre-serial production standard.

The overall objectives of this Strategic Topic are:

- Design and development of a fin equipped with HLFC technology for long-term operational demonstration.
- Development of all necessary tests, reports, means of compliance to achieve with the HLFC fin an airworthy flight test maturity.
- Development of the complete manufacturing process suitable for pre-serial production of the HLFC fin.
- Support to data acquisition/ reduction during long-term flight testing to mature the design of the HLFC fin to a maturity level which allows a direct and rapid full certification of this component.

2. Scope of work

- Flight Physics support to multidisciplinary design (aero-loads-structure) of a fin equipped with HLFC technology which obtains airworthy level to enter into a long-term operation test schedule. The 1st level responsibility for the complete design is on Airbus side.
- Flight Physics support to build-up the full pre-serial manufacturing chain (incl. jigs&tools, supplier chain, etc.) based on the chosen design principle and materials. The 1st level responsibility for building-up the manufacturing chain is on Airbus side plus other aerospace companies. As mentioned before, the manufacturing chain shall be compliant to industrial serial-production standard.
- Assessment of the level of HLFC-system degradation during operation with respect to technology degradation, maintenance aspects, cleaning aspects through dedicated short-haul flights making use of the test set-up (HLFC fin, 2nd segment and flight test platform) developed and used in the EU L2 project AFLoNext. The 1st level responsibility and execution of this flight test campaign will be organized between Airbus and the applicant(s) through the existing Design Organisation Approvals of each organisation.
- Development and preparation of all necessary flight test- and health monitoring instrumentation associated with the HLFC technology.
- Flight Physics support to design the route to certification for the fin equipped with HLFC technology and preparation of the long-term operation flight test schedule together with an

airline. The 1st level responsibility and execution of the validation and certification process for the long-term operation flight test schedule will be organized between Airbus and airline and managed with the respective authorities through the existing Design Organisation Approvals of each organisation.

- Aerodynamic analysis of the long-life behaviour of the HLFC technology applied on fin studied by long-haul flights in a long-term operation flight test schedule.
- Net drag-energy assessment of passive vs. active HLFC suction solution.
- Support to an overall assessment of the HLFC technology applied on fin (technology value assessment) to determine the net benefit of the technology on overall aircraft level (considering recurring costs, non-recurring costs, maintenance costs, economic aspects, etc.).
- Flight Physics support to the determination of the operational envelope of aircraft equipped with HLFC technology on fin. The reference for this task is that the component (HLFC fin) has achieved pre-serial status after completion of long-term operation flight test schedule.

3. Skills, capabilities

- It is expected that the applicant(s) has (have) a strong background and experience in overall aircraft design and the related field of flight physics.
- The applicant(s) shall be able to demonstrate sound technical knowledge in the field of the proposed contributions, he shall be able to demonstrate that this knowledge is widely recognized.
- The applicant(s) shall demonstrate experience in-depth project management in time, cost and quality together with evidence of past experience in large project participation.
- It is intended that the applicant(s) take(s) also responsibility for work package lead (incl. co-developing the project management plan and closely monitoring the project progress) which in detail has to be defined in the negotiation phase.

Furthermore, the applicant(s) shall have the following special skills in aerodynamic design:

- Shape, component design and structural analysis using CATIA v5, NASTRAN
- High-fidelity aerodynamic CFD skills for modelling and design using hybrid mesh approach
- In-depth knowledge about aircraft design compliant to FAR rules and respective ATA chapters
- Laminar design capability using a suitable tool chain including stability calculations, suction requirements, etc.

The applicant(s) shall use and having access to a large single aisle flight test aircraft whereas an Airbus type of aircraft is preferred.

4. Major deliverables and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type	Due Date
ST-1b - B_D1.4-1	Review of HLFC technology status and proposed structural concept	Report	Dec. 2015
ST-1b - B_D1.4-2	Preliminary Design Concept of flight-worthy fin equipped HLFC technology available	Report	June 2016
ST-1b - B_D1.4-3	Final Design of flight-worthy fin equipped HLFC technology available	Report	Dec. 2016
ST-1b - B_D1.4-4	Assessment of the level of HLFC-system degradation during operation investigated by dedicated short-haul flights making use of the test set-up developed and used in the EU L2 project AFLoNext	Report	March 2018
ST-1b - B_D1.4-5	Aerodynamic analysis of the long-life behaviour of the HLFC technology applied on fin studied by long-haul flights in a long-term operation flight test schedule	Report	Dec. 2018

5. Abbreviations

AFC:	Active Flow Control
AFLoNext:	Active Flow & Loads Control on next generation wing
BR:	Bypass Ratio
CBM:	Condition Based Maintenance
CFD:	Computational Fluid Dynamics
CROR:	Counter Rotating Open Rotor
CS2:	Clean Sky 2
CS2JU:	Clean Sky 2 Joint Undertaking
E2E:	End To End
FP7 L2:	7th European Framework Programme - Level 2 project
HLFC:	Hybrid-Laminar Flow Control
IHMM:	Integrated Health Monitoring and Management
PMT:	Processes Methods and Tools
R&T:	Research and Technology
RANS:	Reynolds-Averaged-Navier-Stokes equations
S/C:	Subcontract
SHM:	Structure Health Monitoring
TRL:	Technology Readiness Level
URANS:	Unsteady Reynolds Averaged Navier–Stokes

III. Advanced HLFC Fin Design Work

Leader and Programme Area [SPD]	LPA		
Work Packages (to which it refers in the JTP)	WP 1.4		
Indicative Topic Funding Value	5 M€		
Leading Company	Airbus		
Duration of the action	5 years	Start Date	1 st April 2015
Date of Issue	5 th June 2014	Call Wave	1

Topic Number	Title		
JTI-CS2-2014-CPW01-LPA-01-03	Advanced HLFC Fin Design Work <i>Structural Design and Manufacturing of an Operational HLFC Fin</i>	Duration	5 years
		Start Date	1 st April 2015

1. Background

The significant drag reduction potential of the HLFC technology was addressed in a number of large R&T programmes in the US and in Europe for more than two decades ago. In 2011 Boeing revealed flight test pictures with a HLFC system applied on the fin of the B787-8 and also advertising this HLFC system as aerodynamic enhancement package for the B787 evolution. Despite this pre-serial example by Boeing and even though the physics and the technical principles are well understood, no “industrial” technology solution could be developed so far to materialize the aerodynamic potential, while keeping the complexity and weight of the required systems low.

Furthermore, the effort and cost to manufacture, operate and maintain these systems need to be brought down to an acceptable level. Boosted by the recent progress to mature the NLF technology for short range large transport aircraft, there is a significant transfer of knowledge and technologies applicable for the HLFC technology. In addition, a set of new technologies in virtually all areas of material processing, manufacturing and automation in combination with new materials open the door to develop industrially viable solutions for the HLFC technology applied on airframe.

Based on the results of the FP7 L2 Project “AFLoNext”, in which the development and the first operational experience with advanced HLFC technology will be acquired, the scope in Clean Sky 2 is to collect long-term operational experience with this technology applied on the fin including issues of airworthiness, respectively certification related issues. In order to provide an essential contribution to accomplish the Technology Readiness Level TRL6 for this technology, further focus of this topic is to develop and design a full manufacturing chain required for an industrial application.

This includes addressing issues of quality standards, efforts in resources, tooling, materials and other resources like water, energy and further.

The purpose of the present topic description is to find Core-Partner(s) in LPA who contribute on a strategic and architecture level on the HLFC subject over a substantial scope of research activities. It is expected that the Core-Partner(s) has sound experience in overall aircraft design for large passenger aircraft and can offer all necessary capabilities, skills and resources to perform technology development on high Technology Readiness Level in a large European research platform. The applying Core-Partner candidate(s) shall have a strong experience to contribute to a multidisciplinary, integrated development and design environment.

It is a clear intention that the Core-Partner(s) to be selected for this topic is taking the responsibility for essential management elements in area of HLFC research and development and the associated organisation according to the project management plan. This is in particular including the readiness to take responsibility in the technical lead of action, through leading work packages or sub work packages, and the definition of topics for Call for Proposal(s) of partners.

The commitment of the proposing candidate shall also firmly include the readiness to follow necessary technical program changes, if required. For this reason, the applying candidate has to

commit for an engagement clearly beyond the expected completion of technical deliveries for the HLFC fin technology scheduled for the end of 2018.

The majority of work and thus the expected contribution and role of the applying Core-Partner candidate(s) described in this topic are essentially linked to work package 1.4 in CS2 LPA “Platform 1”, as displayed in the below figure. All explanations provided in the following and the mentioned work packages (incl. nomenclature) do fully refer to the CleanSky 2 Joint Technical Proposal (JTP), version 4, as the baseline document.

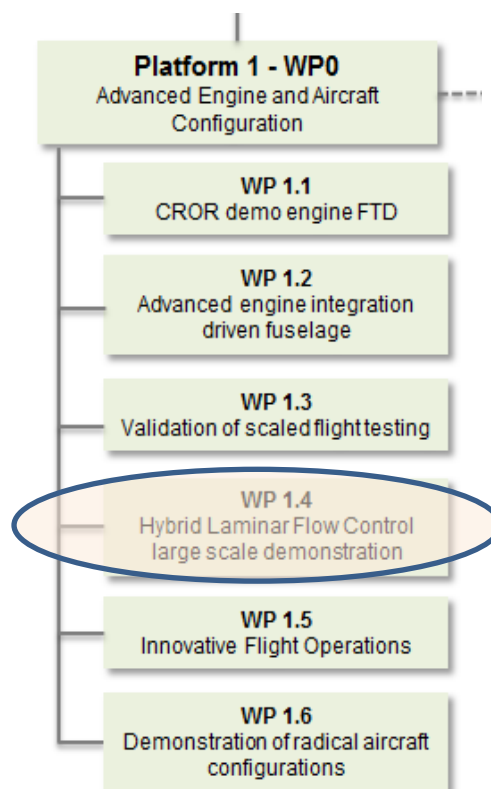


Figure 1. Part of the Work Breakdown Structure relevant for this Strategic Topic

2. Scope of work

As indicated in the background section, the HLFC fin concept to be developed shall have a strong reference in experiences and intermediate results from other previous, respectively actually ongoing major research activities in this field. In particular the FP7 L2 Project "AFLoNext" is provide a considerable basis of knowledge and results with respect to the principle performance and functioning of a HLFC large passenger aircraft fin, yet based on a "Research Type" design modification of a standard Airbus A320 fin.

The majority of research and development work to be addressed in this topic is related to design and develop an HLFC Fin for a large passenger aircraft, type to be defined, that is including the first operational experiences made in the previous programs. Target is to consider and address all aspects of type certification, operational reliability, maintenance and repair and issues of a potential manufacturing in an industrial environment and scale.

The overall objectives of the task to which this topic belongs can be split as follows:

- Design and development of a fin equipped with HLFC technology for long-term operational demonstration.
- Development of all necessary tests, reports, means of compliance to achieve with the HLFC fin an airworthy flight test maturity.
- Development of the complete manufacturing process suitable for serial production of the HLFC fin.
- Support to data acquisition/ reduction during long-term flight testing to mature the design of the HLFC fin to a maturity level which allows a direct and rapid full certification of this component.

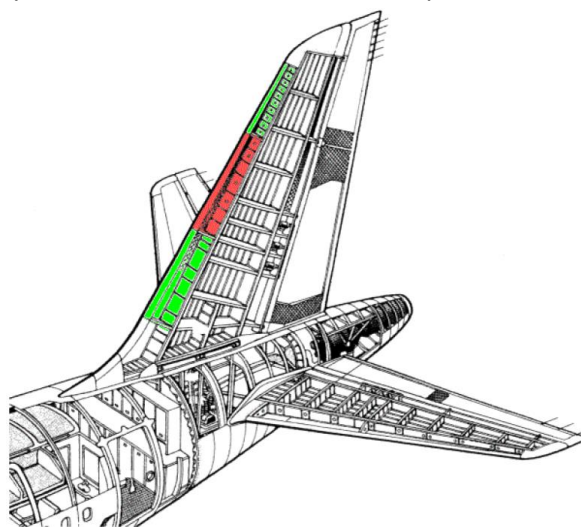


Figure 2. Approach of a research-type HLFC fin concept to be provide operational data to LPA through the FP7 Project AFLoNext

The applying Core-Partner candidate(s) shall provide a proposal how to deal with the subjects listed in the following, yet not exhaustive table of activities. He shall include information providing evidence of his experience and understanding of the key issues to be addressed. The applicant(s) should also add proposals for additional technologies or innovations to be offered to the project in the sense of further added values for the HLFC- Fin technology respectively the targeted demonstrator.

It is intended to assign the successful applicant(s) a coordinating or leading role within work package, including the definition, launch and technical management of Call for Proposal Partners and the coordination of contributions of other LPA consortium member work shares associated to the subject. The details will be defined in the negotiation phase.

The key subjects to be considered as representative for the scope of work and to be treated in the application are:

- Structure design support to multidisciplinary design (aero-loads-structure) of a fin equipped with HLFC technology which obtains airworthy level to enter into a long-term operation test schedule. The 1st level responsibility for the complete design is on Airbus side.
- Principle build-up of the full manufacturing chain (incl. jigs&tools, supplier chain, etc.) based on the chosen design principle and materials in close and interdisciplinary cooperation with Airbus. The 1st level responsibility for building-up the manufacturing chain is on Airbus side. As mentioned before, the manufacturing chain shall be compliant to an industrial application with serial-production standards.
- Structure design support to define the route to certification for the fin equipped with HLFC technology and preparation of the long-term operation flight test schedule together with an airline. The 1st level responsibility and execution of the validation and certification process for the long-term operation flight test schedule will be organized between Airbus and airline and managed with the respective authorities through the existing Design Organisation Approvals of each organisation.
- Structure analysis of the long-life behaviour of the HLFC technology applied on fin studied by long-haul flights in a long-term operation flight test schedule.
- Support to an overall assessment of the HLFC technology applied on fin (technology value assessment) to determine the net benefit of the technology on overall aircraft level (considering recurring costs, non-recurring costs, maintenance costs, economic aspects, etc.).
- Structure design support to the determination of the operational envelope of aircraft equipped with HLFC technology on fin. The reference for this task is that the component (HLFC fin) has achieved pre-serial status after completion of long-term operation flight test schedule.

3. Special skills, capabilities

- The applicant(s) shall be able to demonstrate sound technical knowledge in the field of proposed contributions he shall be able to demonstrate that this knowledge is widely recognized.
- Ability to develop complete manufacturing chains for major airframe components including partner and sub-contractor steering and engagement.
- The applicant(s) shall demonstrate experience in project management in Time, Cost and Quality together with evidence of past experience in large project participation.
- The applicant(s) shall have the following special skills:
- World-class experience in design, manufacturing and assembly of airframe components and structure (incl. jigs and tools) mainly based on composite and metallic materials.
- Shape, component design and structural analysis using CATIA v5, NASTRAN
- Design Organisation Approval available.
- Designated airframe certification specialists (DCS).
- Consolidated background in development of structural virtual and physical tests for aeronautical composite structures and associated technology, full scale validation and certification regarding static, dynamic, fatigue, damage tolerance and residual strength tests.

4. Major deliverables and schedule (estimate)

<i>Deliverables</i>			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
ST-3_D1.4-1	Review of HLFC technology status and proposed structural concept	Report	Dec. 2015
ST-3_-D1.4-2	Preliminary Design Concept of flight-worthy fin equipped HLFC technology available	Report	June 2016
ST-3_D1.4-3	Final Design of flight-worthy fin equipped HLFC technology available	Report	Dec. 2016
ST-3_D1.4-4	All critical jigs, tools in combination with competences and skills available to demonstrate an industrial type of manufacturing	Hardware	June 2018
ST-3_D1.4-5	Structure analysis of the long-life behaviour of the HLFC technology applied on fin studied by long-haul flights in a long-term operation flight test schedule	Report	Dec. 2018

5. Abbreviations

AFC:	Active Flow Control
AFLoNext:	Active Flow & Loads Control on next generation wing
BR:	Bypass Ratio
CBM:	Condition Based Maintenance
CFD:	Computational Fluid Dynamics
CROR:	Counter Rotating Open Rotor
CS2:	Clean Sky 2
CS2JU:	Clean Sky 2 Joint Undertaking
E2E:	End To End
FTD:	Flight Test Demonstrator
FP7 L2:	7th European Framework Programme - Level 2 project
HLFC:	Hybrid-Laminar Flow Control
IHMM:	Integrated Health Monitoring and Management
PMT:	Processes Methods and Tools
RANS:	Reynolds-Averaged-Navier-Stokes equations
S/C:	Subcontract
SHM:	Structure Health Monitoring
TRL:	Technology Readiness Level
URANS:	Unsteady Reynolds Averaged Navier–Stokes

IV. Integrated Engine Mounted Rear End Demonstrator: Component Design, Manufacturing and Test

Leader and Programme Area [SPD]	LPA		
Work Packages (to which it refers in the JTP)	WP 1.1, 1.2		
Indicative Topic Funding Value	7,5 M€		
Leading Company	Airbus		
Duration of the action	9 years	Start Date	1 st April 2015
Date of Issue	13 th of June 2014	Call Wave	1

Topic Number	Title		
JTI-CS2-2014-CPW01-LPA-01-04	Integrated Engine Mounted Rear End Demonstrator: Component Design, Manufacturing and Test <i>This topic consists of 2 modules, please see subsequent pages for modules A to B</i>	Duration	9 years
		Start Date	1 st April 2015

1. Background

The purpose of the present topic description is to find Core-Partner(s) in LPA to contribute on a strategic and architecture level to a wide scope of research and development activities in overall aircraft design for large passenger aircraft. It is expected that the Core-Partner(s) provide(s) all necessary capabilities, skills and resources to perform technology development on high Technology Readiness Level in a large European research platform.

The successful applicant(s) of this Topic shall be a key actor to design, manufacture and test a large integrated fuselage rear-end demonstrator specifically designed to carry advanced next generation engines at the back end of a large transport aircraft fuselage. This work shall be done in close collaboration with Airbus, engine manufacturers and other dedicated Core-Partners.

The principle of operation requires strong experience in working in a multidisciplinary and integrated design environment. The role of the successful applicant(s) to this topic shall be also to bring an essential contribution to the technical management and further programme planning. The coordination of other contributing partners in the course of the programme is an explicit part of the scope of this Topic.

The strategic role in this topic is explicitly founded on a number of fundamental and long termed contributions to demonstrators and technologies in LPA Platform 1.

For the sake of clarity, these specific hot spots of work will be explained by “Modules” in the following description of this Topic. The scope, described work content, objectives and the mentioned work packages (incl. nomenclature) fully refer to the Joint Technical Proposal (JTP), version 4, as the baseline document.

The Core-Partner(s) to be identified for this topic shall take a strategic role in each of the modules. Even though the technical work described in the modules is typically connected to a technical demonstrator roadmap of less than the full duration of Clean Sky 2, the commitment of the proposing candidate shall firmly include to be ready to follow possible necessary technical program changes, which means the applying candidate has to commit for an engagement to the full program lifetime.

Explicitly included in both Modules in this Topic is the readiness to take responsibility in the technical lead of action, through leading work packages or sub work packages, and the definition of topics for Call for Proposals of partners.

Module / Indicative share of total CP activity	Title
Module A ~65%	Design, manufacturing, testing and simulation of rear end components <i>Linked to WP1.2 CFRP rear end – “Large scale demonstration of Rear Mounted Engine rear fuselage”</i>
Module B ~35%	Design and manufacturing of components for CROR FTD <i>Linked to WP1.1 CROR FTD – “In Flight CROR demonstration”</i>

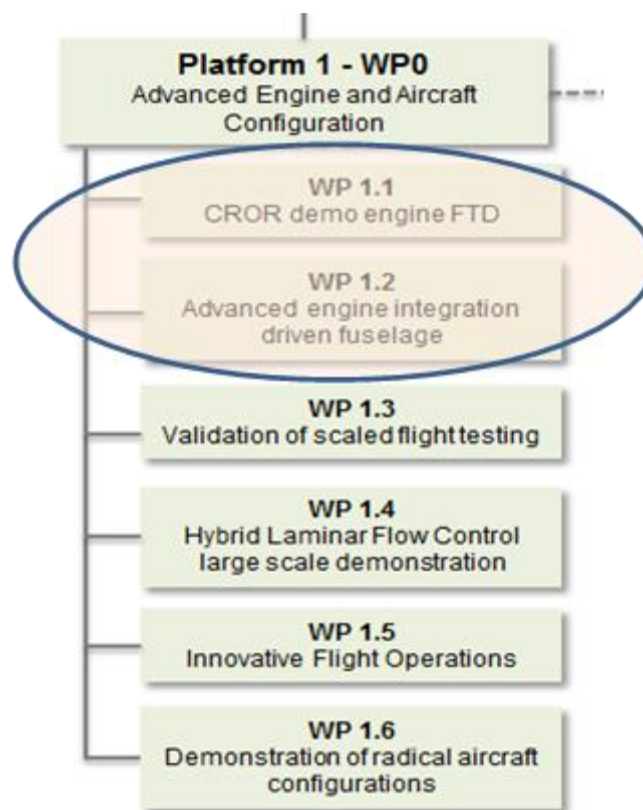


Figure 1. Part of the Work Breakdown Structure relevant for this Strategic Topic

2. Scope of work

The main objective of this topic is to design and manufacture major structural components for the integration of an open rotor engine to the rear part of a fuselage at full scale.

The target is to achieve TRL 6 at the end of the tests. For a better description of the tasks, the topic is divided in 2 parts ("Modules"), one for the ground test of the aircraft rear end structure, including design, manufacturing and testing, and one for the flight test of the engine, including again design, manufacturing and preliminary testing for a pylon to prepare the flight test bed. These activities will be carried out in strong cooperation with the airframe- and the engine manufacturer. The content and scope of the two Modules will be outlined in the following two paragraphs. The required skills and competences are compiled in one paragraph at the end of this Topic description.

a) Module A

Design, manufacturing and testing of rear end components

linked to

WP1.2 CFRP rear end – "Large scale demonstration of Rear Mounted Engine rear fuselage"

Work packages and tasks related to design, manufacturing and testing of subcomponents for aircraft rear End: fuselage and empennage, pylon and engine mounts, shielding measures, for full scale rear-end demonstrator to reach TRL5/6 maturity level.

The main objective of this WP is to validate critical disruptive technology, required to secure safe and efficient CROR integration on rear end of an aircraft, at representative scale, to reach TRL5 and TRL 6 readiness level.

The first objective is to demonstrate that disruptive structure & shielding architecture reaches necessary safety level requested by certification, with minimum penalty at aircraft level. The rear end demonstrator provides the required representative framework for performing static, fatigue and dynamic tests to validate that structure and critical interfaces are able to sustain required loads conserving integrity. In addition, it provides representative hardware scale to perform CROR engine debris impact test to demonstrate structural integrity after impact.

The second objective is to demonstrate the feasibility and efficiency of the multifunctional physical integration of structure and systems to avoid integration showstoppers and secure minimum cost and penalty both at manufacturing and operability. A full scale demonstrator of the (Aircraft Rear End Rear end) rear fuselage and empennage where engine is installed, including systems will provide the required representative environment to perform assembly manufacturing testing of such systems, system performance testing and operability process validation.

An additional objective of the rear-end demonstrator is to fulfil "transversal" needs of partial or total testing for other technologies necessary for innovative engine integration as cabin acoustics, vibration propagation and vibration comfort, innovative repair technologies, health monitoring and others

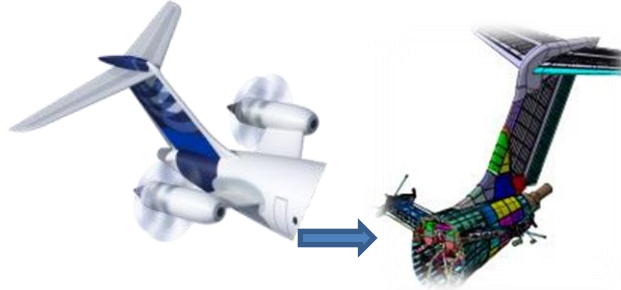


Figure 2 – The key objective of the activity in Module A is to design, manufacture and test a large scale demonstrator of a representative large aircraft rear-end ready to carry advanced engines.

▪ **Scope of work**

- Perform specific Design and manufacture of a part of the components of the real size, fully representative innovative Carbon fibre reinforcement plastic CFRP rear-end (CROR rear mounted engine) and sub components elements including associated metallic reinforcements parts. Design and manufacturing of tools required to manufacture and assembly Rear End demonstrator.
- Perform the development of robust add-on concepts with respect to high and low energy impact on rear-end as well as development and demonstration of concepts for shielding health monitoring (SHM).
- Perform the specific design and manufacturing of add-on innovative shielding elements submitted to high energy impact as CROR engine debris impacts, bird impact, etc. for rear-end configuration.
- Manufacture and design subcomponent and the entire section fully representative of the test bench and perform full representative Rear end static load test, data reduction and test report to validate the static strength of the components and interfaces of the CROR rear-end mounted engine.
- Design the test bench design for the Rear End subcomponent and entire section, to be fully representative, manufacture and test. Reduce data and report on test, to validate the fatigue strength of the components and interfaces of the CROR rear-end mounted engine.
- Design a representative test bench for rear-end subcomponent and entire section, manufacture and perform dynamic test, data reduction and test report to validate the dynamic and blade imbalance behaviour, dynamic loads evaluation and strength of the components and interfaces of the CROR Rear End mounted engine.
- Design a representative test bench for rear-end subcomponent and entire section full representative test bench design and manufacturing and perform residual strength test, data reduction and test report to validate the residual strength of the components and interfaces of the CROR rear-end mounted engine, after large damage due to CROR engine

debris impact and other high energy impact.

- Design a representative test bench for rear-end subcomponent, then manufacture, and perform Impact test data reduction and test report to validate the impact behavior of engine high, medium and low energy debris as blade, turbine disc and other debris. In addition, perform impact characterisation test for medium and high level representative composite-composite structures.
- Participate with Airbus to the test set-up, its definition, and perform pre and post-test simulations and virtual test, and process data for specified large scale tests.

▪ **Major Deliverables and schedule (estimate)**

<i>Deliverables</i>			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
ST-4 - A_D1.2-1	Rear end Sub-component parts Design	Sub component CAD drawings or 3D models	2016
ST-4 - A_D1.2-1	Rear end Sub-component parts Manufacturing	Sub component Physical sub-components	2017
ST-4 - A_D1.2-1	High energy impact test Rear End component & test bench manufacturing	Test bench hardware deliver, test results and test report	2016
ST-4 - A_D1.2-1	Rear End component Static strength test	Component static loads test results and test report	2018
ST-4 - A_D1.2-1	Rear End component Residual strength test after large damage	Component Residual strength test results and test report	2018
ST-4 - A_D1.2-1	Rear End component Fatigue strength test	Component Fatigue loads test results and test report	2019

b) Module B

Design and manufacturing of components for CROR FTD

linked to

WP1.1 CROR FTD – “In Flight CROR demonstration”

The powerplant integration activities in Clean Sky 2 are aiming at identifying and developing innovative integration solutions for both future large by-pass ratio turbofan engines and contra rotating open rotor engines.

The scope of powerplant integration activities within the Large Passenger Aircraft is the maturation of solutions up including flight testing or ground testing of key enablers for future application. Also, in parallel to the technologies, the scope of activity contains the development of capabilities to enable those demonstrations in the most efficient manner.

The scope of this document is related to activities in LPA IDAP WP 1.1 CROR Demo Engine FTD (see JTP v4 paragraph 6.5.2). It consists in Design For Manufacturing and Manufacturing of pylon primary structure sustaining the demo engine + assembly of primary structure with pylon leading edge and trailing edge + systems installation on the pylon.

▪ Scope of work

The scope of work is to design and manufacture a highly instrumented pylon sustaining the demo engine.

- Design For Manufacturing (DFM) and Manufacturing of pylon primary structure sustaining the demo engine.
- Assembly of pylon primary structure with pylon training edge and pylon leading edge.
- System installation on the assembled pylon:
 - Fuel pipes
 - Oil pipes
 - Air pipes
 - Harnesses for electrical disribution
 - Flight Test Instalation sensors
 - Flight Test Installation harnesses

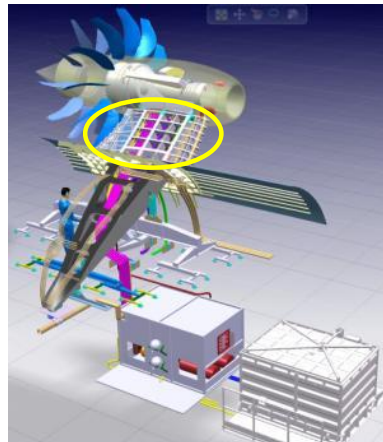


Fig. 3: Sketch of the structure and system integration of the CROR-demon engine to the flying test bed and the structural part to be developed in Module B (Pylon marked in yellow)

Two structures will have to be produced, one for the Ground Test Bench (pass-off test) and one for the Flight Test Demonstrator. The structural definition will be the same for both but the System Installation may be slightly different (different routings).

- **Major deliverables and schedule (estimate)**

<i>Deliverables</i>			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
ST-4 – B_D1.1-1	Core-Partner(s) contribution detailed description (content, deliverables , planning)	Report	Oct 2015
ST-4 – B_D1.1-2	Contribution to CROR FTD concept freeze review	Data Report	Nov 2016
ST-4 – B_D1.1-3	Contribution to CROR FTD preliminary design review (PDR)	Data Report	Nov 2017
ST-4 – B_D1.1-4	Contribution to CROR FTD conceptual design review (CDR)	Data Report	2018
ST-4 – B_D1.1-5	Contribution to CROR FTD test readiness review (TRR)	Data Report	2019
ST-4 – B_D1.1-6	Contribution to CROR FTD data release & pre-analysis	Data Report	2021

3. Skills, capabilities

▪ General

- It is expected that the applicant(s) has a strong background and experience in overall aircraft design and the related field of flight physics.
- The applicant(s) shall provide evidence of a sound technical knowledge in the field of proposed contributions, he shall be able to demonstrate that this knowledge is widely recognized.
- The applicant(s) shall provide evidence of strong experience in project management in “time, cost and quality” together with evidence of substantial contribution in large research and development projects in the associated area.
- It is intended that the applicant(s) take(s) also responsibility for work package lead (incl. co-developing the project management plan and closely monitoring the project progress) which in detail has to be defined in the negotiation phase.

▪ Related to Module A

- World-class experience in design and manufacturing major aero-structure subcomponents as fuselage and empennage sections, reinforced components and panels, boxes, secondary structures and other Rear End sub-structures parts mainly on composite and metallic materials.
- Top engineering level capabilities with extensive experience in CFRP and metallic Airframe design & stress, manufacturing (incl. jigs and tools, components manufacturing and assembly), designated certification specialists (DCS) for engine/airframe application certification.
- Extensive experience in development and certifying of shielding and innovative structure able to resist high energy debris impact as bird impact and other high energy debris impacts.
- Consolidated background in development of structural virtual and physical Tests for Aeronautical composite structures and associated technology, full scale validation and Certification: Static, dynamic, Fatigue, Damage Tolerance and Residual Strength tests.

▪ Related to Module B

- Design, Stress justification, manufacturing and component testing of medium to large Airframe component within pluri-partner cooperative environment. Use of common tools for configurations management, DMU and project managements.

4. Abbreviations

AFC:	Active Flow Control
AFLoNext:	Active Flow & Loads Control on next generation wing
BR:	Bypass Ratio
CBM:	Condition Based Maintenance
CFD:	Computational Fluid Dynamics
CROR:	Counter Rotating Open Rotor
CS2:	Clean Sky 2
CS2JU:	Clean Sky 2 Joint Undertaking
DMU:	Digital Mock-Up
E2E:	End To End
FTD:	Flight Test Demonstrator
FP7 L2:	7th European Framework Programme - Level 2 project
HLFC:	Hybrid-Laminar Flow Control
IHMM:	Integrated Health Monitoring and Management
PMT:	Processes Methods and Tools
RANS:	Reynolds-Averaged-Navier-Stokes equations
S/C:	Subcontract
SHM:	Structure Health Monitoring
TRL:	Technology Readiness Level
URANS:	Unsteady Reynolds Averaged Navier–Stokes

V. PoWer Turbine of the Flight Demonstrator Contra Rotative Open Rotor (CROR) engine

Leader and Programme Area [SPD]	LPA		
Work Packages (to which it refers in the JTP)	WP 1.1.3. Contra-Rotating Open Rotor (CROR) Demo Engine		
Indicative Topic Funding Value	5 M€		
Leading Company	SAFRAN/Snecma		
Duration of the action	9 years	Start Date	April 1 st 20 15
Date of Issue	July 9 th 2014	Call Wave	1

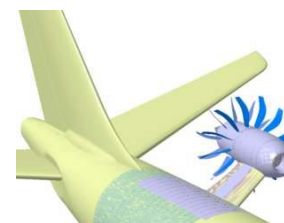
Topic Number	Title		
JTI-CS2-2014-CPW01-LPA-01-05	PoWer Turbine of the Flight Demonstrator Contra Rotative Open Rotor (CROR) Engine	Duration	9 years
		Start Date	April 1 st 2015

Short description and terms of reference

The present topic refers to the Joint Technical Programme (JTP V4), addressing two Systems and Platforms Demonstrators (SPD):

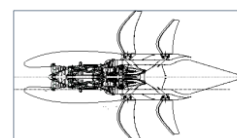
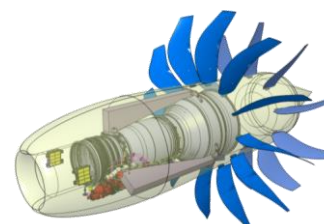
- **IADP_LPA: Platform 1 - Advanced Engine and Aircraft Configuration, WP1.1.3.**

This Platform will provide the environment to explore and validate the integration of the most fuel efficient propulsion concept for next generation short and medium range aircraft: the CROR engine. The large scale demonstration will include extensive flight testing with a full size demo engine (see below) mounted on the Airbus A340-600 test aircraft.



- **ITD Engine – WP1 Open Rotor Flight Test, 2014-2021.**

A second version of a Geared Open Rotor demonstrator carrying on Clean Sky SAGE 2 achievements with the aim to validate TRL 6 will be tested on ground and then on the Airbus A340 flying test bed (see IADP LPA Programme). From initial SAGE 2 demonstrator some engine modifications introducing various improvements, control system update, and engine/aircraft integration activities will be necessary in order to obtain a flightable demonstrator (Flight Test Demo-FTD) and particularly :



- a demonstrator having compatible interfaces with the Airbus A340 flying test bed and its systems

- a demonstrator whose parts are flightable parts

On the Engine Side, the objectives are to mature the following technologies, up to TRL6 through Flight Testing of the FTD CROR Engine on the Airbus A340 flying test bed:

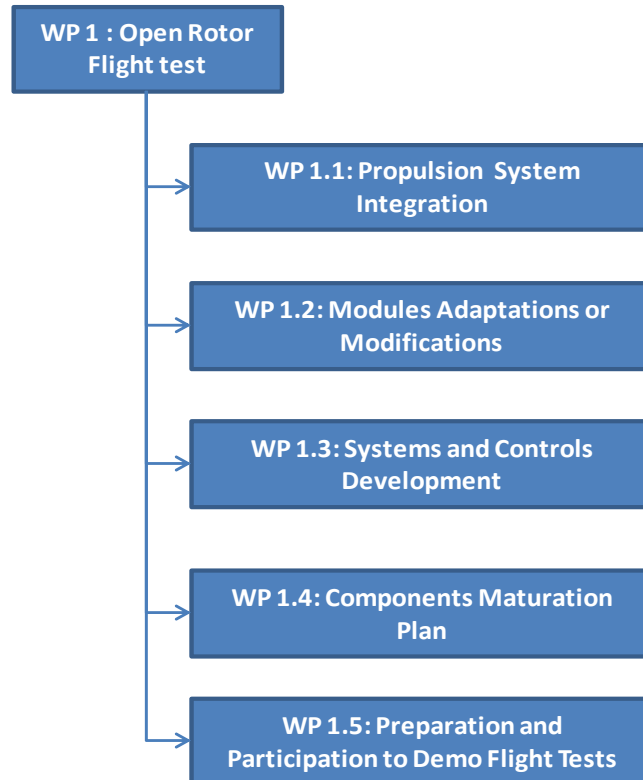
- New composite open rotor blades concepts optimized for aerodynamic and acoustics
- Pitch control full system for counter rotating blades
- Counter rotating structures supporting the blades
- High power gear box with counter rotating outputs
- High efficiency PoWer Turbine (PWT)
- Engine integration and installation in rear fuselage area

On the Aircraft/Engine Side, the objectives are to evaluate and demonstrate CROR performance noise and vibration behavior through Flight Testing of the FTD CROR Engine on the Airbus A340 flying test bed.

In the frame of this Call for Core-Partner(s), the Applicant(s) will be responsible for the tasks linked to PWT Module:

- **Power Turbine** for Flight Test CROR Demo Engine (FTD)
 - Design adaptation of the turbine for FTD CROR Engine taking into account airworthiness studies conclusions and available test data, PWT providing energy to propellers through Power GearBox (PGB) will need a design adaptation and some partial tests to check the ability to fly.
 - Manufacturing of new parts for demo PWT
 - Assembly / instrumentation of this demo PWT module
 - Partial tests to check the ability to fly
- **Power Turbine** for Scale 1 Aerodynamic Component Tests in cold flowpath
 - Design of a set of blades for a typical “product” turbine
 - Manufacturing of this typical “product” turbine and rig adaptations
 - Aero cold test of this typical “product” turbine in order to assess the aerodynamic efficiency of this component

The associated tasks are part of WP1.1, WP1.2, WP1.4 and WP1.5 as described in the Work Breakdown Structure (WBS) hereafter:



1. Background

SAGE 2 Ground Test Demonstrator includes one high-speed **PWT** which is one major element of the power system of this Contra Rotative Open Rotor. This high-speed PWT extracts power from the exhaust hot flow of the Gas Generator. The two other elements of the power system are the PoWER GearBox (PGB) and the shafts transmitting power to propeller blade system.

2. Scope of work

The Scope of work deals with the following strategic objectives:

- On Engine Side, to mature high efficiency PWT Technologies, up to:
 - TRL6 through Flight Testing of the FTD CROR Engine on the Airbus A340. The flying test will be made with the FTD CROR Engine including the new high speed PWT
 - TRL5 for “Product Engine” PWT through Scale 1 Aerodynamic Component Tests of “Product Engine” PWT aiming at demonstrating aerodynamic performance (i.e. efficiency) of the typical “product” turbine in order to check maturity of the design for future product
- *As part of WP 1.1.3.1/WP 1.1. of the ITD Engine (Propulsion System Integration), it will cover:*
 - Analysis of flight test airworthiness
 - Analysis of available test data on SAGE 2 PWT
 - Participation in Propulsion System Integration studies, consisting in :
 - Summarizing lessons learnt on SAGE 2 PWT
 - Taking into account these results into the updating of integration studies for FTD CROR
- *As part of WP 1.1.3.2/WP 1.2. of the ITD Engine (Modules Adaptations or Modifications), it will cover:*
 - Adaptation of Design or Re-Design of PWT for Flight Test CROR Demo Engine (FTD)
 - Manufacturing of one PWT for Flight Test CROR Demo Engine (FTD) and spare parts. The manufacturing of the PWT module for FTD includes:
 - the rotor of the turbine (discs, blades, trunnion with labyrinth seals, turbine support shaft)
 - the stator of the turbine (turbine outer case, vanes, adaptations for instrumentation)
 - Assembly and instrumentation of PWT for Flight Test CROR Demo Engine (FTD)
- *As part of WP 1.1.3.4 (Components Maturation Plan) /WP 1.4. of the ITD Engine, it will cover:*
 - Design or Re-Design of PWT for future CROR Product Engine.
 - This step is necessary to improve maturation on future “Product Engine” PWT, giving that FTD CROR PWT has specificities due to the confluence zone at the exit of SAGE 2

- Gas Generator that feeds the turbine.
- Manufacturing of one PWT for Scale 1 Aerodynamic Component Tests in cold flowpath and spare parts.

The Manufacturing of one **PWT** for Scale 1 Aerodynamic Component includes :

 - the rotor of the turbine (discs, blades, trunnion with labyrinth seals, turbine support shaft)
 - the stator of the turbine (turbine outer case, vanes ,adaptations for instrumentation)
 - the adaptations parts of the machine to be tested, enabling the integration and assembly of the Turbine Specimen in the Turbine Rig (forward and aft adaptation sleeves, driving shaft, bearings, bearing supports, air and oil sumps)
 - the adaptations of the Rig enabling the Turbine aerodynamic test: adaptations of Air system, Oil system, measurements and data acquisition system
- Assembly and instrumentation of PWT for Scale 1 Aerodynamic Component Tests
- Scale 1 Aerodynamic Component Tests of PWT.
- *As part of WP 1.1.3.5 (Preparation and participation in Demo Flight Tests) /WP 1.5 of the ITD Engine:*
 - Support for PWT Module during Flight Test CROR Demo Engine (FTD) including prior Pass-Off test in Ground Test Facility. this support includes :
 - participation in reviews before CROR Pass-Off test and Flight Test (Test Readiness Reviews) for PWT
 - monitoring of PWT parameters during CROR Pass-Off test and Flight Test
 - participation in inspection of PWT parts if needed
 - repair or replacement of PWT parts and measurements if needed
 - delivery of two test reports for PWT Module: CROR PWT Pass-Off test and Flight Test Reports

3. Special skills, capabilities

- Expertise and skills
 - Design of aeronautic commercial engine high temperature bladed rotors including expertise on aerodynamics, thermal, mechanics, vibrations aspects
 - 3D modeling
 - Manufacturing of aeronautic commercial engine parts or modules
 - Inspection means including blades and disks and expertise for quality assessment of produced part
 - Material characterization especially for fatigue characteristics (HCF, LCF) instrumentation and component test capability
 - Quality manual to ensure quality of design, materials, manufacturing, instrumentation, test, conditioning and shipping of hardware
 - Risk Analysis, failure mode and effect analysis
 - Demonstrated capability to deliver a PWT able to be integrated on a scale 1 engine installed on an actual scale 1 flying test bed
- Capabilities and track records
 - Company qualified as an Aeronautic Supplier for Product Commercial Engine Parts
 - Company certified for Quality regulations (ISO 9001, ISO 14001) and for Design of engine subsystems or modules (CSE, Part 21, Part 145)
- Competences to deal with risks associated to the action:
 - At SPD level:
 - Background in Research and Technology (R&T) for aeronautics especially on Open Rotor Demonstrators or Rotating parts,
 - Lessons learnt on achievements in the frame of former R&T European programs (FP7 or Clean Sky): delivery of instrumented part(s) or module(s) for scale 1 engine demonstrator
 - Experience on design, manufacturing and testing of large high speed turbine modules for aero engines and of associated engine parts (power 15 Mw, maximum outer diameter around 1,5m, weight 300 kg)
 - At applicant level:
 - Background in R&T for aeronautics
 - Lessons learnt on former R&T European program (FP7 or Clean Sky)
 - Project Management capability for 10M€ project
 - Quality Management capability for 10M€ project
 - Exchange of Technical Information through network: 3D models of parts, Interface Control Documents, Digital Mock-Up, 3D models available at CATIA format



- Expertise available in the internal audit team
- Resources in house for design, manufacturing, material, instrumentation, tests
- Intellectual property and confidentiality
 - Snecma will own the specification, while the Core-Partner(s)) will own the technical solutions that he will implement into the corresponding subsystems.
 - Snecma information related to this programme must remain within the Core-Partner(s); in particular, no divulgation of this topic to Core-Partner affiliate(s) will be granted.
- Ownership and use of the demonstrators
 - The Core-Partner(s) will deliver demonstrator parts to Snecma. Each part integrated or added in the demonstrator will remain the property of the party who has provided the part.
 - Notwithstanding any other provision, during the project and for five (5) years from the end of the project, each party agrees to grant to Snecma a free of charge right of use of the relevant demonstrator and its parts.
 - After the end of the period, each party may request the return of the parts of the demonstrator(s) that it provided. If the concerned parts are returned, no warranty shall be given or assumed (expressed or implied) of any kind in relation to such part whether in regard to the physical condition, serviceability, or otherwise.

4. Major deliverables and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type*	Due Date
D1	Analysis of flight test airworthiness: conclusions of studies for PWT of FTD CROR demo engine	R	Q4 2015
D2	Analysis of available test data on SAGE 2 PWT: Report of lessons learnt especially versus capacity of Ground Test Demo (GTD) PWT and ability of GTD PWT for Flight Test	R	Q3 2016
D3	PWT for FTD CROR demo engine: concept and feasibility report	R and RM	Q4 2016
D4	Adaptation of Design or Re-Design of PWT for Flight Test CROR Demo Engine (FTD): Preliminary Design Review and Report	R and RM	Q1 2017
D5	Design of PWT for Flight Test CROR Demo Engine (FTD): Critical Design Review and Detailed Design Report	R and RM	Q1 2018
D6	PWT: components tests plan PWT components tests Readiness review	R and RM	Q3 2017
D7	PWT: hardware delivery to Aerodynamic component test facility	D	Q3 2017
D8	PWT: Aerodynamic component testing completed - completed with hardware - inspection review and report	RM	Q4 2018
D9	PWT: component test reports	R	Q1 2019
D10	PWT: hardware delivery to engine test stand	D	Q1 2019
D11	Engine readiness review Documentation for PWT: - Delivered Hardware status - Instrumentation - Engine Test Plan requirements	R and RM	Q3 2019
D12	Engine Pass-Off test (ground test) report for PWT	R	Q3 2020
D13	Engine Flight Test report for PWT	R	Q4 2021
D14	Lessons learnt for PWT	R	Q2 2022

*Type:

R: Report

RM: Review Meeting

D: Delivery of hardware/software

Topics for Core-Partners Call 1



5. Schedule

	2014		2015				2016				2017				2018				2019				2020				2021				2022			
	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Demonstrator ground test (Clean Sky SAGE 2)																																		
Analysis of Gap between GT and FTD specifications																																		
Preliminary design phase																																		
Detailed Design																																		
Manufacturing																																		
Instrumentation Build 2 (start of assembly flight engine)																																		
Rig tests for permit to fly																																		
Design, manufacturing & assembly of test bench adaptation																																		
Pass-off test																																		
Flight Test Demo - First Test																																		
Flight Test Result analysis																																		
TRL Progresses	4										5																6							

VI. Rotating Frames of the flight demonstrator Contra Rotating Open Rotor engine

Leader and Programme Area [SPD]	LPA		
Work Packages (to which it refers in the JTP)	WP 1.1.3 Contra Rotating Open Rotor Demo Engine		
Indicative Topic Funding Value	5 M€		
Leading Company	SAFRAN/Snecma		
Duration of the action	9 years	Start Date	April 1st 2015
Date of Issue	July 9 th 2014	Call Wave	1

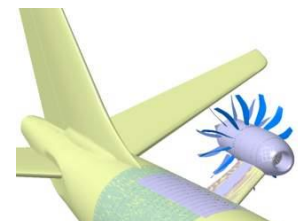
Topic Number	Title		
JTI-CS2-2014-CPW01-LPA-01-06	Rotating Frames of the flight demonstrator Contra Rotating Open Rotor engine	Duration	9 years
		Start Date	April 1st 2015

Short description and terms of reference:

This topic refers to the Joint Technical Programme (JTP V4), addressing two Systems and Platforms Demonstrators (SPD):

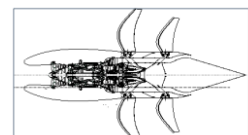
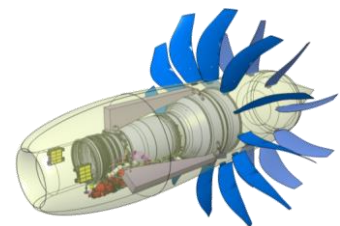
▪ IADP_LPA: Platform 1 - Advanced Engine and Aircraft Configuration, WP1.1.3.

This Platform will provide the environment to explore and validate the integration of the most fuel efficient propulsion concept for the next generation short and medium range aircraft: the Contra Rotating Open Rotor (CROR) engine. The large scale demonstration will include extensive flight testing with a full size demo engine (see below) mounted on the Airbus A340-600 test aircraft.



▪ ITD Engine – WP1 Open Rotor Flight Test, 2014-2021.

A second version of a Geared Open Rotor demonstrator following on the Clean Sky SAGE 2 achievements with the aim of validating TRL 6 will be tested on ground and then on the Airbus A340 flying test bed (see IADP LPA programme). Starting from the initial SAGE 2 demonstrator certain engine modifications which introduce various improvements, control system update, and engine/aircraft integration activities will be necessary in order to obtain a flightable demonstrator (Flight Test Demo) and particularly:



- A demonstrator that has compatible interfaces with the Airbus A340 flying test bed and its systems
- A demonstrator whose parts are flightable parts

On the Engine Side, the objectives are to mature the following technologies, up to TRL6 through Flight Testing of the Flight Test Demo (FTD) CROR Engine on the Airbus A340 flying test bed:

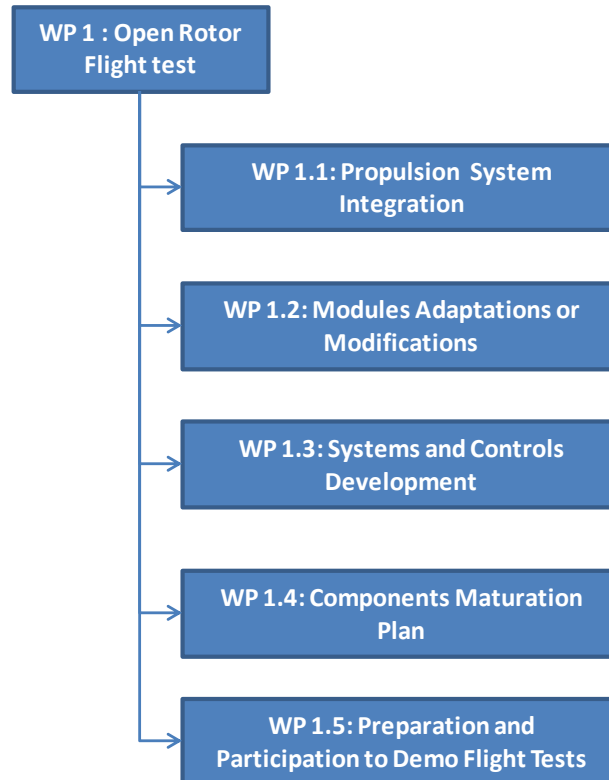
- New composite open rotor blades concepts optimized for aerodynamic and acoustics
- Pitch control full system for counter rotating blades
- Counter rotating structures supporting the blades (Rotating Frames)
- High power gear box with counter rotating outputs
- High efficiency PoWer Turbine (PWT)
- Engine integration and installation in rear fuselage area

On the Aircraft/Engine Side, the objectives are to evaluate and demonstrate CROR performance noise and vibration behavior through flight testing of the FTD CROR Engine on the Airbus A340 flying test bed.

In the frame of this Call for Core-Partner(s), the Applicant(s) will be responsible for the tasks linked to:

- **Forward and Aft RF Modules for FTD CROR Engine:**
 - Design adaptation or re-design of the Forward and Aft Rotating Frame (RF) for FTD CROR Engine, taking into account airworthiness studies, conclusions and available test data; Forward and Aft RF providing energy to the propellers from the PWT and Power GearBox (PGB) will need a design adaptation or a re-design and some partial tests to check its ability to fly
 - Manufacturing of new parts for Forward and Aft RF demo
 - Assembly/instrumentation of these Forward and Aft RF demo modules
 - Partial tests to check the ability to fly, for example material or process tests on samples
- **Forward and Aft RF Modules for Scale 1 Component Tests:**
 - Manufacturing of the Forward and Aft RF modules/parts and rig adaptations
 - Assembly and instrumentation of the Forward and Aft RF modules/parts and rig adaptations
 - Scale 1 Component Tests: these tests are mechanical tests aiming at demonstrating the mechanical capacity of the Forward and Aft RF modules for flight demonstration. The tests can either be structural tests [static tests or dynamic fatigue test] or/and spin tests [overspeed test and/or fatigue test] depending on the technology of RF modules

The associated tasks are part of WP1.1, WP1.2, WP1.4 and WP1.5 as described in the Work Breakdown Structure (WBS) hereafter:



1. Background

The SAGE2 Ground Test Demonstrator (GTD) includes two RF Modules: a Forward RF Module and an Aft RF Module, each being respectively part of Forward and Aft propeller rotors of this CROR. Both Modules are rotating structural modules that are transmitting power from a power system output to a propeller blade system. Each (Forward/Aft) Module consists mainly of:

- An Aft RF
- Intermediate rings linking the RF with the driving shaft
- A Sleeve Frame linking the RF to the Ring supporting the blades

2. Scope of work

The scope of work deals with the following strategic objectives:

- **On the Engine Side**, to mature counter rotating structures supporting the blades (RF) up to TRL6 through Flight Testing of the FTD CROR Engine on the Airbus A340. The flying test will be made with the FTD CROR Engine including the new Forward and Aft RF
- **On the Aircraft/Engine Side**, to contribute to the objectives of evaluating and demonstrating CROR performance noise and vibration behavior through Flight Testing of the FTD CROR Engine on the Airbus A340 flying test bed

- *As part of WP1.1.3.1/WP 1.1 of the ITD Engine (Propulsion System Integration), it will cover:*
 - Analysis of flight test airworthiness of Forward and Aft RF Modules
 - Analysis of available test data on the SAGE 2 Forward and Aft RF
 - Participation in Propulsion System Integration studies, consisting of:
 - Summarizing lessons learnt on SAGE 2 Forward and Aft RF
 - Taking into account these results in the update of the integration studies for the FTD CROR
- *As part of WP 1.1.3.2/WP 1.2. of the ITD Engine (Modules Adaptations or Modifications), it will cover:*
 - Adaptation of Design or Re-Design of Forward and Aft RF for FTD CROR Engine
 - Manufacturing of one Forward and one Aft RF for FTD CROR Engine and the spare parts which include:
 - One Forward and one Aft RF parts
 - The Sleeves Frames rotor 1 and 2
 - Equipment of the Forward and Aft RF modules (including rings, seals, bolts and nuts)
 - Spare parts To Be Defined
 - Assembly and instrumentation of **the Forward and Aft RF modules** for FTD CROR Engine
- *As part of WP 1.1.3.4 (Components Maturation Plan) /WP 1.4. of the ITD Engine, this will cover:*
 - Design of Rig Adaptations for Scale 1 Component Tests of Forward RF and Aft RF
 - Manufacturing of one Forward RF Module and one Aft RF Module for Scale 1 Component Tests and manufacturing of spare parts. The manufacturing for the Scale 1 Component Tests includes :
 - The Forward and one Aft RF parts
 - The Sleeves Frames rotor 1 and 2
 - Equipment of the Forward and one Aft RF modules (including rings, seals, bolts and nuts)
 - Spare parts to be defined
 - The rig adaptations parts of the Forward RF Module and one Aft RF Module to be tested, enabling the integration, assembly and test of the respective Modules in the respective Rigs
 - Assembly and instrumentation of one Forward RF Module and one Aft RF Module for Scale 1 Component Tests
 - Scale 1 Component Tests of one Forward RF Module and one Aft RF Module
- *As part of WP 1.1.3.5 (Preparation and participation in Demo Flight Tests) /WP 1.5 of the ITD Engine:*
 - Support for the Forward RF and the Aft RF Modules during FTD CROR Engine including prior Pass-Off test in Ground Test Facility. This support includes:
 - Participation in reviews before CROR Pass-Off test and Flight Test (Test Readiness Reviews) for Forward RF and Aft RF Modules

- Monitoring of Forward RF and Aft RF Modules parameters during CROR Pass-Off test and Flight Test
- Participation in inspection of Forward RF and Aft RF Modules if needed
- Repair or replacement of Forward RF and Aft RF Modules and measurements if needed
- Delivery of two test reports for Forward RF Module and Aft RF Module:
 - CROR Forward RF and Aft RF Modules Pass-Off test report
 - CROR Forward RF and Aft RF Modules Flight test report

3. Special skills, capabilities

- Expertise and skills
 - Design of aeronautic commercial engine structural parts or modules: aerodynamics, mechanics, vibrations
 - 3D modeling
 - Manufacturing of aeronautic commercial engine structural parts or modules
 - Inspection means and expertise for quality assessment of produced part
 - Material characterization especially for fatigue characteristics (HCF, LCF)
 - Instrumentation and component test capability
 - Quality manual to ensure quality of design, materials, manufacturing, instrumentation, test, conditioning and shipping of hardware
 - Risk analysis, failure mode and effect analysis
 - Demonstrated capability to deliver both structural and rotating parts able to be integrated on an actual scale 1 flying test bed
- Capabilities and track records
 - Company qualified as an Aeronautic Supplier for Product Commercial Engine Parts
 - Company certified for Quality regulations (ISO 9001, ISO 14001) and for Design of engine subsystems or modules (CSE, Part 21, Part 145)
 - Competences to deal with risks associated to the action (both at SPD and applicant level)
- Competences to deal with risks associated to the action
 - At SPD level:
 - Background in Research and Technology (R&T) for aeronautics especially on Open Rotor Demonstrators or Rotating parts
 - Lessons learnt on achievements in the frame of former R&T European programs (FP7 or Clean Sky): delivery of instrumented part(s) or module(s) for scale 1 engine demonstrator
 - Experience on design, manufacturing and testing of large rotating structural engine parts (outer diameter 1,6m., weight 300kg)
 - At applicant level:
 - Background in R&T for aeronautics
 - Lessons learnt on former R&T European program (FP7 or Clean Sky)
 - Project Management capability for 10M€ project
 - Quality Management capability for 10M€ project
 - Exchange of technical information through network: 3D models of parts, Interface

Control Documents, Digital Mock-Up, 3D models available at CATIA format

- Expertise
 - Available in the internal audit team
 - Resources in house for design, manufacturing, material, instrumentation, tests
- Intellectual property and confidentiality
 - Snecma will own the specification, while the Core-Partner(s) will own the technical solutions that he will implement into the corresponding subsystems.
 - Snecma information related to this programme must remain within the Core-Partner(s) ; in particular, no divulgation of this topic to Core-Partner affiliate(s) will be granted.
- Ownership and use of the demonstrators
 - The Core-Partner(s) will deliver demonstrator parts to Snecma. Each part integrated or added in the demonstrator will remain the property of the party who has provided the part.
 - Notwithstanding any other provision, during the project and for five (5) years from the end of the project, each party agrees to grant to Snecma a free of charge right of use of the relevant demonstrator and its parts.
 - After the end of the period, each party may request the return of the parts of the demonstrator(s) that it provided. If the concerned parts are returned, no warranty shall be given or assumed (expressed or implied) of any kind in relation to such part whether in regard to the physical condition, serviceability, or otherwise.

4. Major deliverables and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type	Due Date
D1	Analysis of flight test airworthiness: conclusions of studies for forward and aft RF of FTD CROR demo engine	R	Q4 2015
D2	Analysis of available test data on SAGE2 RF: report of lessons learnt especially versus capacity of GTD RF and ability of GTD RF for Flight Test	R	Q3 2016
D3	RF for FTD CROR demo engine: concept and feasibility report	R and RM	Q4 2016
D4	Adaptation of design or re-design of forward RF and Aft RF for FTD CROR Engine: Preliminary Design Review and Report	R and RM	Q1 2017
D5	Design of forward RF and Aft RF for FTD CROR Engine: Critical Design Review and Detailed Design Report	R and RM	Q1 2018
D6	Forward RF and Aft RF components tests plan Forward RF and Aft RF components Tests Readiness Review	R and RM	Q3 2017
D7	Forward RF and Aft RF hardware delivery to component test facility	D	Q3 2017
D8	Forward RF and Aft RF components testing completed: - completed with hardware - inspection review and report	RM	Q4 2018
D9	Forward RF and Aft RF component test reports	R	Q1 2019
D10	Forward RF and Aft RF hardware delivery to engine test stand	D	Q1 2019
D11	Engine readiness review Documentation for Forward RF and Aft RF : - Delivered Hardware status - Instrumentation - Engine Test Plan requirements	R and RM	Q3 2019
D12	Engine Pass-Off test (ground test) report for Forward RF and Aft RF	R	Q3 2020
D13	Engine Flight Test report for Forward RF and Aft RF	R	Q4 2021
D14	Lessons learnt for RF	R	Q2 2022

*Type:

R: Report

RM: Review Meeting

D: Delivery of hardware/software

[illegible]

VII. Airframe, Cabin/Cargo and System integration Architecture

Leader and Programme Area [SPD]	LPA		
Work Packages (to which it refers in the JTP)	WP2.1 - WP2.2 - WP 2.3 Platform 2		
Indicative Topic Funding Value	5 M€		
Leading Company	Airbus		
Duration of the action	9 Years	Start Date	1 st April 2015
Date of Issue	20.05.2014	Call Wave	1

Topic Number	Title		
JTI-CS2-CPW01-LPA-02-01	Airframe, Cabin/Cargo and System integration Architecture	Duration	9 Years
		Start Date	1 st April 2015

Short description and terms of reference:

The aim of the present topic is to develop new concepts for System, Cabin/Cargo and Fuselage Integration for a Large Passenger Aircraft. This new concept should include innovative materials, smart/ lean manufacturing processes and an optimized integrated approach between Cabin/ Cargo, System and Structure including the development of multifunctional solutions as a key element to foster a fully new lever for fuselage optimization. Within this call a new disruptive concept has to be defined.

Detailed development and the building of the demonstrator will be part of other calls. The demonstrator itself will be an aft aircraft section showing disruptive concepts for structure, cabin& cargo and system integration.

Today's state of the art requirements for structure, cabin& cargo and system integration have to be analyzed and challenged to minimize and optimize clearances, find solutions for load path optimization and find new assembly concepts which are lighter and optimize the manufacturing process.

To verify the benefits coming out of this new architecture, tests will be made on the demonstrator. The Tests for this integrated approach has to be defined. Scope and benefits of tests have to be defined. The test approach will also embody the objectives of CS2 by ensuring that novel and optimized approaches are developed which reduce the cost and lead time of the test process.

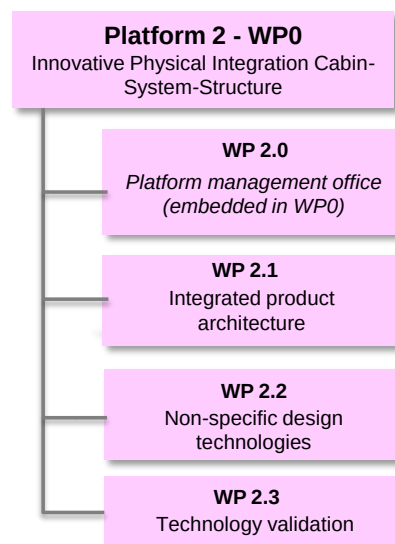
The project will be a joint development with Airbus.

1. Background

The approach of the Innovative Physical Integration Cabin-System-Structure Platform 2 is to provide the frame for large-scale complex demonstration, as a segmented feature demonstrator (refer to JTP Figure 6.26 WP 2.3.1.1) or at full size for validation and testing on the ground. The target is to validate high potential combinations of airframe structures using advanced materials and applying innovative design principles in combination with the most advanced electrical system architecture in combination with the next generation cabin. The driver of this approach is attain up to a double digit fuel burn reduction by substantially reducing the use of secondary energy, applying low weight systems and system architecture/integration and to be able to cash in weight potentials in the structural design of the fuselage and the connected airframe structure.

Platform 2 is organized along three Work Packages, which reflect the three main project phases:

- “WP 2.1 Integrated Product Architecture” is dedicated to a multi-disciplinary optimization approach for a fuselage-cabin-systems integrated product architecture, able to pave the way to a step-change in aircraft overall physical design.
- “WP 2.2 Non-Specific Design Technologies” will develop the individual technology concepts that are key to materialise the integrated product definition of WP2.1.
- “WP 2.3 Technology Validation” comprises all demonstrator activities, in order to validate the multifunctional solutions and to prove their manufacturability in a pre-production environment.

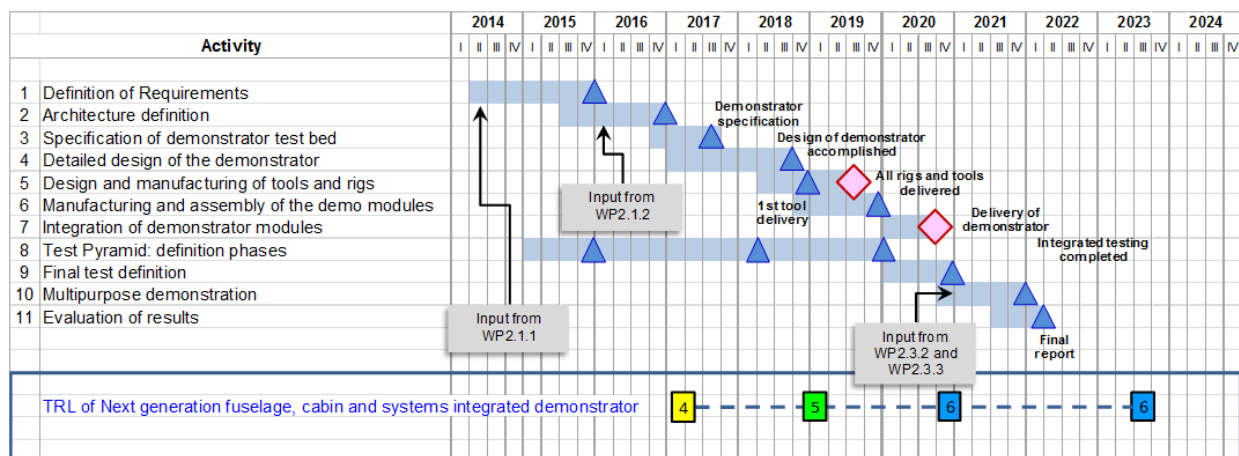


2. Scope of work

The Core-Partner(s) is (are):

- Responsible for the deliverables within the concept phase (activities “1. Definition of requirements” and “2. Architecture definition” in the planning below),
- Involved and contributing to the other phases of the next generation fuselage structure, cabin, cargo and physical systems integrated Demonstrator.

Next Generation Fuselage, Cabin and Systems Integrated Demonstrator



Demonstration Objectives (JTP 6.6 II)

The approach of the “Innovative Physical Integration Cabin-System-Structure” Platform is to provide the framework for development, integration and demonstration of the best candidate technologies. This will deliver the concept for the next generation of an integrated fuselage structure, cabin, cargo and physical system able to deliver up to a double digit fuel burn reduction.

The Core-Partner(s) will be responsible for the following tasks:

- Define and work out Functional & Operational requirements across the different ATA chapter (e.g. ATA25, ATA53, ATA92, ATA21,...) questioning the given state of the art requirements keeping in mind the certification basis, supported and validated by Airbus.
- Develop and Investigate Innovative overall fuselage airframe architecture with new integration approaches;
- Selection of Material options for fuselage structure, including integration of multi-functionalities;
- For the integrated structure, cabin and system integration approach, the concepts for advanced manufacturing means and methods will be defined to achieve:
 - high production rates,
 - reduced costs,
 - reduced and optimized installation effort.

The development of the new integrated approach has to be in line with a lean Aircraft manufacturing process.

- Figures for weight savings, reduced production costs and operational efficiency have to be reported;
- Develop a Technology Verification & Validation plan for the final concept that reflects the defined functional and operational requirements and perform virtual and physical full scale V&V tests in a close to real environment;
- Means of compliance for certification of highly integrated multifunctional concept have to be worked out;

Role of the Core-Partner(s) - Management and Coordination:

- Project progress to be reported on a regular basis.
 - Manage and coordinate the progress meetings.
 - Manage and coordinate project activities on related subjects.
 - Support and coordinate the reviews.
- Manage the configuration management process.

3. Special skills, capabilities – See list under Paragraph II

▪ **General skills, capabilities**

- It is expected that the applicant(s) has (have) a strong background and experience in overall aircraft design.
- Furthermore, the applicant(s) shall be able to demonstrate sound technical knowledge in the field of proposed contributions, he shall be able to demonstrate that this knowledge is widely recognized.
- The applicant(s) shall demonstrate experience in-depth project management in Time, Cost and Quality together with evidence of past experience in large project participation.
- It is intended that the applicant(s) take(s) also responsibility for work package co lead (incl. co-developing the project management plan and closely monitoring the project progress) which in detail has to be defined in the negotiation phase.

▪ **Special Skills**

The applicant(s) has (have):

- the capability for stress analyses (airframe and installation cabin or systems),
- A/C manufacturing engineering capabilities,
- capabilities to manufacture A/C Structure parts,
- capabilities in architecture and integration of fuselage, cabin and system,
- capabilities in Material & Processes to select possible combinations,
- capabilities in test definition to develop a test baseline for the demonstrator,
- Project management skills as requested in chapter 2),
- Automation specialists to optimize the concept between manufacturing and development of the new integrated approach,
- capabilities in certification (FAR 25),
- capabilities and knowledge in requirement based engineering.

4. Major deliverables and schedule (estimate)

<i>Deliverables</i>			
<i>Ref. No.</i>	<i>Title – Description</i>	<i>Type</i>	<i>Due Date</i>
	Requirement documents	Report	T0 + 6
	Means of compliance document	Report	T0 + 24
	Enabler selection list (including assessment)	Report	T0 + 18
	Demonstrator Baseline Description (including fall-back solutions)	Report	T0 + 24
	Engineering Description (including manufacturing & built concept)	Report	T0 + 36
	Definition dossier	Report	T0 + 48
	Test Definition Document	Report	T0 + 60
	Test Specimen	Hardware	T0 + 72
	Test results	Report	T0 + 96
	Final Evaluation	Report	T0 + 108

5. Short description of Documents

- **Requirements documents:** Requirement baseline to start detailed design.
- **Means of compliance:** Description of candidate airframe & cabin architecture solutions, and providing evidence for compliance with certification rules.
- **Enabler selection list:** Trade-off studies of the candidate architectures and necessary key enabling technologies. Concept selection based on evidence provided for weight, RC and NRC savings.
- **Demonstrator baseline description:** Description of the demonstrator (materials, stress assumptions, function of the demonstrator).
- **Engineering description:** Product breakdown structure to show build concept.
- **Definition Dossier:** Drawings, bill of materials.
- **Test definition document:** Test description (e.g. Number of tests, expected results)

6. Definition of Terms

CS2JU: Clean Sky 2 Joint Undertaking

LPA: Large Passenger Aircraft

IADP: Innovative Aircraft Demonstration Platform

ATA: Air Transport Association

V&V: Verification & Validation

A/C: Aircraft

FAR25: Federal Aviation Regulation part 25

RC: Recurrent Costs

NRC: Non-Recurrent Costs

VIII. Cabin & Cargo Functional Systems & Operations

Leader and Programme Area [SPD]	LPA		
Work Packages (to which it refers in the JTP)	2.2.4 - 2.2.5 - 2.2.6 Platform 2		
Indicative Topic Funding Value	6,5 M€		
Leading Company	Airbus		
Duration of the action	8 Years	Start Date	1 st April 2015
Date of Issue	20.05.2014	Call Wave	1

Topic Number	Title		
JTI-CS2-CPW01-LPA-02-02	Cabin & Cargo Functional Systems & Operations	Duration	8 Years
		Start Date	1 st April 2015

Short description and terms of reference

The present topic is targeting at a partnership collaboration within the IADP* Large Passenger Aircraft. Within the Platform 2, there is a need for a strong industrial partner to realise the integrated Cabin & Cargo approach. To take on this strategic commitment, the successful applicant will be actively involved in investigating, developing and manufacturing activities within three main areas of research, which have been identified as key elements to achieve the integrated and multifunctional Airframe-Cabin-System concept.

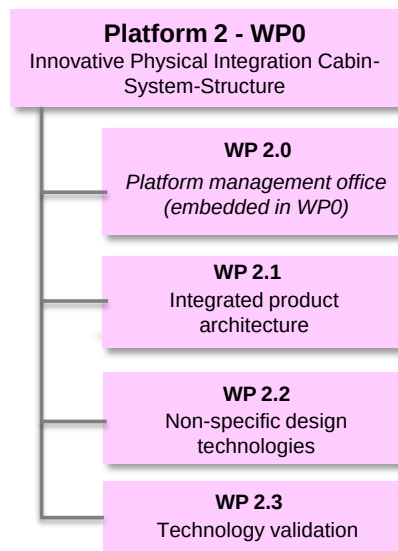
Area / Indicative share of total CP activity	Title
Area A / ~45%	Moveable Passenger Service Unit Satellite Housing <i>Linked to LPA WP2.2.5 Customization technologies</i>
Area B / ~45%	Fuel cell technologies for decentralized power supply system <i>Linked to LPA WP2.2.4 Interface technologies</i>
Area C / ~10%	Environmentally-friendly cargo fire suppression system <i>Linked to LPA WP2.2.6 Airframe and Cabin & Cargo Operations</i>

* IADP: Innovative Aircraft Demonstrator Platform

1. Background

Platform 2 is organized along three Work Packages, which reflect the three main project phases:

- “WP 2.1 Integrated Product Architecture” is dedicated to a multi-disciplinary optimization approach for a fuselage-cabin-systems integrated product architecture, able to pave the way to a step-change in aircraft overall physical design.
- “WP 2.2 Non-Specific Design Technologies” will develop the individual technology concepts that are key to materialise the integrated product definition of WP2.1.
- “WP 2.3 Technology Validation” comprises all demonstrator activities, in order to validate the multifunctional solutions and to prove their manufacturability in a pre-production environment.



The scope of common research work shall mainly focus on key enabler technologies within the cabin and cargo domain of Platform 2.

Passenger cabins have not been addressed within Clean Sky and are key for a safe, healthy and comfortable travel environment for the passengers, as well as an ergonomic, fatigue-proof working environment for the cabin crew. Furthermore, the cabin & cargo domain can significantly contribute to the ecological goals of Clean Sky 2 by fuel efficiency through weight reduction, cost-efficient and resource-conserving manufacturing processes and dedicated use of energy-efficient, environmentally friendly materials.

2. Scope of work

Within Platform 2, the topic addresses a collaboration in “WP 2.2 Non-Specific Design Technologies”. The research work shall target at investigating and adapting new technologies that enable the development and manufacturing of the most advanced cabin & cargo functional elements, suitable to realize the envisaged highly integrated and multifunctional Airframe-Cabin-System concept defined in WP 2.1. Highest potential benefits in weight, cost and manufacturing time savings shall be provided, while nevertheless increase operational efficiency and travel comfort.

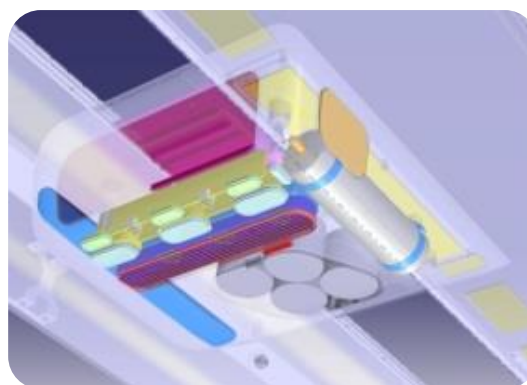
From today’s perspective and without prejudging the outcome of the concept phase in WP2.1, this Call comprises the following topics, which have been identified as key functional elements:

- **Moveable PSU Satellite Housing**

Background: As part of “WP2.2.5 Customization technologies”, a moveable PSU satellite housing shall provide all passenger functionalities offered to the passengers today (except for the loudspeakers which are located in the lining parts). In order to allow the satellite being moved, an eased assembly and de-assembly mechanism with interacting levers shall be integrated.

Passenger service functionalities to be provided include the passenger individual fresh air supply – which shall be realized as functional air outlets/nozzles. In order to provide hoseless and tubeless supply of fresh air a special solution with automatically activated valves shall be realized.

Further functionalities to be integrated are: OLED displays on satellite front (for passenger information and signs and IFE) and side (for seat row numbering), adjustable reading lights and a O2 release latch which shall enable emergency oxygen supply via three technologically independent ways of O2 release. This includes a regular O2 door latch release via the cabin management system and a wireless activation – both without cabling – only in cases of power failure an additional (cabled) safety relevant data path connected to the essential routing is activated.



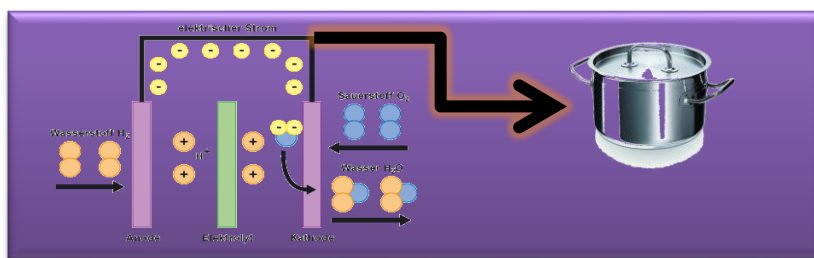
Within this topic the research work shall focus on: the development and manufacturing of a linearly moveable and fully integrated Passenger Service Unit (PSU), development of the associated electronic equipment, reduction of Printed Circuit Boards (PCB) and weight, development of oxygen components, PSU satellite housing development and integration of fixation system.

- **Fuel Cells in Galley**

Background: Galleys are large electrical consumers. They use about 30 % of the overall electrical load in an aircraft. Power supply is realised by feeders connecting the galleys in the cabin with the primary electrical power distribution center, which receives the power from the electrical engine generators.

The trend towards more electric aircraft will increase the overall power demand to be covered by the engine generators and the electrical network. As the existing electrical architecture will reach its limits new concepts are necessary.

Within “WP 2.2.4 Interface Technologies”, decentralised power supply concepts with fuel cells integrated in the galleys shall be investigated as an interesting alternative. Due to the point-of-use generation of power the electrical wiring in the aircraft can be reduced. Potential benefits are weight reduction, faster cabin reconfiguration and reduced installation effort. Fuel cells are power sources with higher efficiency compared to engine generators and zero local emissions and therefore could significantly contribute to long-term air traffic sustainability.

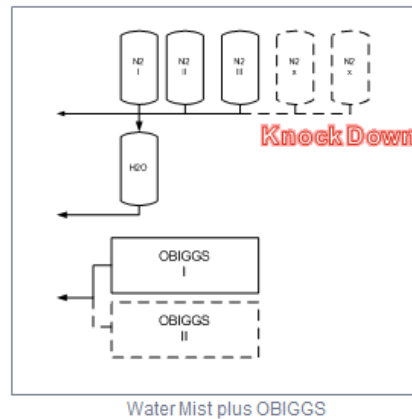


Within this topic the research work shall focus on: the development of fuel cell technologies for decentralised power supply systems, e.g. for galleys.

- **Halon-free, environmentally friendly cargo fire suppression system**

Background: Use of Halons for cargo hold fire protection will be prohibited for future new aircraft type designs due to environmental regulations. Another issue is risk associated with the long term availability of Halons. Halon stocks are decreasing due to the ban on Halon production that was put in place back in 1994. Today recycled Halons are the only sources of supply.

Cargo hold fire suppression systems must operate over a wide temperature range and they must ensure a homogeneous agent distribution in the entire cargo hold over the required time. The fire suppression performance of the replacement candidates and its distribution patterns must be thoroughly evaluated with extensive testing, also taking into account environmental and toxicological parameters. As part of “WP2.2.6 Airframe and Cabin & Cargo Operation”, the challenge is to design and develop a system that is economically viable, environmentally friendly and provides the same high level of safety and reliability than today’s Halon fire suppression systems.



Within this topic the research work shall focus on: an Onboard Inert Gas Generation System (OBIGGS) able to perpetuate nitrogen enriched air as part of a halon-free, environmentally friendly cargo fire suppression system.

The above list of strategic areas may not be exhaustive and could be subject to extension, depending on the concept definition as outcome of the concept phase in WP2.1.

3. Special skills, capabilities - See list under Paragraph II

General skills, capabilities:

- Applicant(s) is (are) expected to have a strong background and experience in cabin & cargo interior and systems design.
- Applicant(s) shall be able to demonstrate sound technical knowledge in the field of proposed contributions and that this knowledge is widely recognized.
- Applicant(s) shall demonstrate in-depth experience in project management in terms of time, cost and quality, together with evidence of past experience in large-size, transnational, multi-disciplinary projects.
- In addition, Applicant(s) shall take responsibility for work package co-lead (incl. co-developing the project management plan and closely monitoring the project progress), which in detail needs to be defined in the negotiation phase.

With regard to special skills, the applicant(s) shall be able to demonstrate:

- capabilities and knowledge in requirement based engineering,
- systems/modules manufacturing engineering capabilities,
- stress analyses capabilities with regard to cabin/cargo or systems installation,
- knowledge in collaborative environment infrastructure, data management, integration, security, communication means and standards between various actors and sources,
- knowledge in multidisciplinary integration of technical and operational functions,
- experience in the human-machine-interface definition

4. Major deliverables and schedule (estimate)

<i>Deliverables</i>			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
	Requirement documents	Report	T0 + 9
	Selection list of enabler technologies (including assessment)	Report	T0 + 15
	Experimental process and trials definition	Report	T0 + 18
	Test infrastructure definition	Report	T0 + 30
	Modules/Systems test specimen	Hardware	T0 + 48
	Integration and test environment	Hardware	T0 + 54
	Pre-integration test results	Report	T0 + 60
	Final integration test results	Report	T0 + 90
	Final Evaluation	Report	T0 + 96

5. Definition of Terms

LPA: Large Passenger Aircraft

IADP: Innovative Aircraft Demonstration Platform

PSU: Passenger Service Unit

OLED: Organic Light-Emitting Diode

IFE: In-Flight Entertainment

PCB: Printed Circuits Board

OBIGGS: Onboard Inert Gas Generation System

Clean Sky 2 – Regional Aircraft IADP

I. Development of Advanced Systems Technologies and Hardware/Software for the Flight Simulator and Iron Bird Ground Demonstrators for Regional Aircraft

Leader and Programme Area [SPD]	REG		
Work Packages (to which it refers in the JTP)	R- IADP WP2.2, WP2.3, WP2.4, WP3.3, WP3.4		
Indicative Topic Funding Value	5 M€		
Leading Company	Alenia Aermacchi S.p.A		
Duration of the action	7 years	Start Date	April 2015
Date of Issue	9 July 2014	Call Wave	1

Topic Number	Title		
JTI-CS2-CPW1-REG-01-01	Development of Advanced Systems Technologies and Hardware/Software for the Flight Simulator and Iron Bird Ground Demonstrators for Regional Aircraft	Duration	7 years
		Start Date	April 2015

Short description and terms of reference:

In the framework of Regional Aircraft IADP, the present topic is addressed to the development of:

- innovative Systems technologies, in particular concerning Electrical Landing Gear and Flight Control System topics, as well as Hardware/Software to build up an innovative Ground Demonstrator- named “Iron Bird”- that integrates the following systems: Flight Control, Electrical and Landing Gear.
- software of advanced avionic functions, to be integrated in an existing Regional Flight Simulator, as well as realistic simulation models to improve the representativeness of such Simulator in order to support the validation of advanced avionics technologies for regional aircraft.

The activity aims to mature technologies to TRL 5 by developing prototype components/functions and performing their integration and testing on the Ground demonstrator (Regional Flight Simulator or Iron Bird) allowing technology verification and validation in a relevant environment. Furthermore, the Iron Bird ground demonstrator will support the permit-to-fly achievement for the demo flight configuration of the R-IADP Flight Test Bed#1 (FTB#1).

The main activities are in the following work packages of the R-IADP work breakdown structure:

- WP 2.2 REGIONAL AVIONICS
- WP 2.3 ENERGY OPTIMIZED REGIONAL AIRCRAFT
- WP 2.4 INNOVATIVE FCS
- WP 3.3 FLIGHT SIMULATOR

➤ WP 3.4 IRON BIRD

1. Background

The role of the IADP dedicated to regional aircraft is to validate the integration of technologies at a further level of complexity than currently pursued in Clean Sky GRA so as to drastically de-risk their integration on future products.

The Regional Aircraft IADP demonstrations will be built by integrating several advanced technologies and solutions, pursuing an integrated and synergic approach with the ITDs. In fact, several technological developments for Regional Aircraft will take place in Airframe and System ITDs in strong interaction and collaborative attitude with the other leaders.

In the R-IADP, the individual Technologies Developments for Regional A/C are arranged along with 8 “Waves” and several individual roadmaps which will be developed in synergy with other ITDs, in particular Airframe ITD and Systems ITD. The WBS for technologies development (WP2) within the R-IADP is the following:

- WP 2.1 ADAPTIVE ELECTRIC WING
- WP 2.2 REGIONAL AVIONICS
- WP 2.3 ENERGY OPTIMIZED REGIONAL AIRCRAFT
- WP 2.4 INNOVATIVE FCS

The high-level WBS of WP3 demonstration is the following:

- WP 3.1 AIR VEHICLE TECHNOLOGIES FTB#1
- WP 3.2 FUSELAGE / CABIN INTEGRATED GROUND DEMO
- WP 3.3 FLIGHT SIMULATOR
- WP 3.4 IRON BIRD
- WP 3.5 INTEGRATED TECHNOLOGIES DEMONSTRATOR FTB#2

This topic will address activities relevant to:

- REGIONAL FLIGHT SIMULATOR (REF. JTP R-IADP WP 3.3)
- REGIONAL IRON BIRD (REF. JTP R-IADP WP 3.4)

As well as some associated technological development contributions to these demonstrators from WPs:

- WP 2.2 REGIONAL AVIONICS
- WP 2.3 ENERGY OPTIMIZED REGIONAL AIRCRAFT
- WP 2.4 INNOVATIVE FCS

These technological developments are complementary to the ones performed by Systems ITD for Regional Aircraft IADP.

For future regional aircraft, the development of innovative/advanced Avionic and System technologies to be validated and demonstrated through the above mentioned demonstrators has a very high strategic importance and their maturation will be addressed thanks to the contribution of the selected Core-Partner(s) and Systems ITD.

“Regional Flight Simulator” ground demonstration rationale

Starting from the *Clean Sky* GRA Flight Simulator, the R-IADP Leader will set up and use an advanced Regional Flight Simulator to demonstrate new cockpit interaction concepts as well as advanced avionics functionalities and to validate, at simulation level, *Clean Sky 2* technologies, belonging to WP2.2 Regional Avionics (ref. JTP chp.7.5.2.I.ii).

Main requirements for the technologies evolution will come from:

- AVIONIC FUNCTIONS (WP2.2.1 AND WP2.2.3)
- INNOVATIVE FLIGHT DECK SOLUTION (WP2.2.2)

In addition to internal link within R-IADP, additional requirements may be defined in Systems ITD (i.e. WP1- Avionics Extended Cockpit).

The main target benefits are:

- Safety
- Pilot workload reduction
- Pilot Situation awareness improvement
- Operational cost

“Regional Iron Bird” ground demonstration rationale

An advanced on ground demonstration is an essential step towards the optimization and validation of Regional Aircraft advanced flight control system configuration and interacting aircraft systems incorporating innovative technologies enabling the application of the All/More Electrical Regional Aircraft Concept such as the Electro-mechanical Actuation (for Flight Control and Landing Gear), the Enhanced Electrical Power Distribution and Power/Load Management.

A Ground demonstrator, named Iron Bird, shall allow to integrate, optimize and validate flight control system and interacting aircraft systems, Electrical and Landing Gear. It is the physical integration of these systems, with each laid out in relation to the actual configuration of the aircraft, and all components installed according to the same requirement of the real airframe.

The Iron Bird shall include aircraft model and the simulation of aerodynamic loads on the control surfaces.

According to the above, the Iron Bird is expected to be the ground demonstrator of innovative technologies developed in WP2 of R-IADP (ref. JTP chp. 7.5.2.1.iii and iv) . It will allow the TRL improvement and at same time will support permit to fly achievement for the demo flight configuration of FTB#1 through extensive tests. In particular, the main technologies expected to be integrated and demonstrated with the Iron Bird are the following ones:

- FLIGHT CONTROL SYSTEM (WP 2.4)
- ELECTRICAL LANDING GEAR (WP 2.3.2)
- ENHANCED ELECTRICAL POWER DISTRIBUTION & LOAD MANAGEMENT (WP2.3.4.2)

2. Scope of Work

The selected Core-Partner(s)) will have a strategic role by:

- Coordinating and performing the technological activities of the R-IADP WP 2.3.2 – Electrical Landing Gear.
- Contributing to the technological activities of the R-IADP WP 2.3.4.2 - Enhanced Electrical Power Distribution & Load Management.
- Contributing to the technological activities of R-IADP WP 2.2 – Regional Avionics.
- Contributing to the technological activities of R-IADP WP 2.4 – Innovative FCS.
- Contributing to the demonstration activities of R-IADP WPs 3.3 – Flight simulator.
- Contributing to the demonstration activities of R-IADP WP 3.4 – Iron Bird.
- Participating to the Management Committee of R-IADP WP 2 “Technologies Development” and WP3 “Demonstrations “.
- Contributing to the WP 0 “Management”, participating to R-IADP Steering Committee and Consortium Management Committee and assuming full responsibility of the risk management associated to their deliverables.
- Contributing to the launch, management and coordination of CfPs and CFTs where necessary, mainly into the framework of the R-IADP relevant to WPs:
 - 2.3.2 – ELECTRICAL LANDING GEAR
 - 2.4 – FLIGHT CONTROL SYSTEM
 - 3.4 – IRON BIRD

According to final ground demonstrator the detailed proposed work can split in two main frames:

- Regional Flight Simulator (RFS) demonstrator
- Advanced Systems Technologies and “Regional Iron Bird” demonstrator

2.1. “Regional Flight Simulator” (RFS) demonstrator

▪ Introduction

The *Clean Sky 2* Regional Flight Simulator, that will be set up at Alenia Aermacchi premises, will allow the execution of the validation test in a simulation environment representative of regional a/c,

enabling the pilot to evaluate new *Clean Sky 2* technologies from a functional point of view as well as to evaluate all Human Machine Interface (HMI) issues.

The following technologies will be integrated and validated by means of *Clean Sky 2* Regional Flight Simulator (ref. JTP chp.7.5.2.1.ii):

- Avionic functions (WP2.2.1)
- Innovative Flight Deck (WP2.2.2)
- Performance / Health Monitoring (WP 2.2.3)
- Technologies coming from Systems ITD (WP1 – Avionics Extended Cockpit)

▪ **Proposed activities**

The main activities for which Core-Partner(s) involvement is requested are the following:

1. SW development of avionic functions (WP2.2.1 and 2.2.3)
2. Development of simulation models supporting RFS (WP3.3.1)

The Core-partner(s) will operate under Alenia Aermacchi leadership, e.g.: Alenia will manage the above WPs, coordinate relevant technical activities and will be in charge of providing SW requirements and managing activities for SW model integration and validation.

Avionic function SW development

In the frame of WP2.2.1 and 2.2.3, the Core-Partner(s) will be requested to contribute to the SW development of avionic and/or Health Monitoring functions.

The main activities are the following:

- Analysis of Alenia Aermacchi SW requirements
- SW Development
- Support to SW validation/integration

All relevant information (e.g. languages, development environment, and detailed deliverables) will be provided in a dedicated Kick-Off Meeting.

Simulation models for RFS

In the frame of WP3.3, Core-Partner(s) will be requested to develop simulation models (e.g. related to avionics and/or general systems) to be connected to RFS set up at Alenia Aermacchi premises.

Models requirement will be defined in the first phase of the project, starting from the work of WP2.2.

In fact, the main purpose of these models is to increase the representativeness of RFS in the scope of

final demonstration.

The main activities are the following:

- Analysis of Alenia Aermacchi simulation model requirements
- Development of simulation models
- Support to integration of simulation models in RFS

All relevant information (e.g. language, output format) will be provided in a dedicated Kick Off Meeting.

2.2. Advanced Systems Technologies and “Regional Iron Bird” demonstrator

▪ Introduction

The Regional Iron Bird that will be set up at Alenia Aermacchi premises, is expected to be the advanced ground demonstrator of innovative systems technologies developed in WP2 of R-IADP (ref. JTP chp. 7.5.2.1.iii and iv)). In particular the main technologies expected to be integrated and demonstrated with the Iron Bird are the following ones:

- Flight Control System (WP 2.4)
 - Advanced and affordable flight control system architecture for regional A/C
 - Load control and Load Alleviation System (sensor, control laws and actuation for new aerodynamic devices)
 - Electro mechanical Actuation System
- Electrical Landing Gear (WP 2.3.2)
 - Enhanced Landing Gear with Electrically actuated Extension/Retraction System
- Enhanced Electrical Power Distribution & Load Management (WP2.3.4.2)
 - Centralized Primary Electrical Power Center with Decentralized secondary distribution modules
 - Enhanced Electrical Energy Management (E2-EM) concept with utilization of Solid State based controller (SSPC) and Local ultra/super capacitors (as energy buffer during high transitory energy request)
 - Digital GCU/BPCU
 - High/Low Voltage bi-directional converters with cellular approach
 - AC/28VDC conversion & battery charge
 - EWIS critical technologies

In particular, in order to support the demo flight test activity, the Iron Bird configuration shall be able also to integrate in a representative way the delta configuration to be introduced into demo-aircraft performing suitable tests. For FCS the Iron Bird Configuration for flight demo is defined in para 2.2.1.

▪ Proposed activities

The main activities for which Core-Partner(s) involvement is requested are the following:

- Electrical Landing Gear technology Development and manufacturing (WP2.3.2)
- Electro- mechanical Actuation System Technology for FCS Development and manufacturing (WP2.4)
- Development and manufacturing of an advanced ground demonstrator, herein named “Iron bird” for demonstration (WP3.4) of :
 - Electrical Landing Gear technology
 - Enhanced Electrical Power Distribution & Load Management technology
 - Flight Control System technology

a) **Electrical Landing Gear technology Core-Partner(s) detailed activities**

The Core-Partner(s) will be requested to manage and coordinate the technological activities of the R-IADP WP 2.3.2 – Electrical Landing Gear. In this frame, the Core-Partner(s) is expected to perform activities in order to achieve the TRL 4 for the regional Landing Gear electrical Extension/Retraction sub-system. Then integration and testing on Iron Bird will allow to conduct a further step therefore bringing the technology maturity level to TRL5. According to that the Core-Partner(s) will be requested to provide:

- study, design and development of a fully electrical Landing Gear Concept, body gear configuration, for weight saving, noise reduction and further benefits in terms of hydraulic removal and maintenance. That in accordance to the specifications and interface definitions delivered by Alenia Aermacchi
- manufacturing of a prototype test items fully representative of the selected Electrical Landing Gear System at least in terms of weight, form, fit and extension retraction function, including:
 - Main Landing Gears, Nose Landing Gear, Lock/Unlock mechanism
 - Electrically actuated Extension/Retraction System,
- integration on Iron Bird of the above test items for electrical extension/retraction full scale ground test demonstration

Outcomes relevant to Technological studies conducted in CS GRA ITD on development of Electromechanical Actuator for Landing Gear System will be taken into account.

b) Electro Mechanical Actuation System for FCS Technology Core-Partner(s) detailed activities

In the frame of WP2.4, the Core-Partner(s) shall provide:

- Contribution to kinematic studies of LC/LA devices actuation systems following output from Advanced wing for regional A/C studies
- Contribution to requirement definition for Electro- mechanical Actuation System for FCS
- Design, development, manufacturing and integration of the selected prototype EMA for ground test
- Application studies for diagnostic and prognostic approach for EMA

The Core-Partner(s) will operate under Alenia Aermacchi leadership, e.g.: Alenia will manage the relevant WP, coordinate relevant technical activities and will be in charge of providing technology design and integration requirements and finally managing activities for prototype equipment/sub-system integration and validation.

Outcomes relevant to Technological studies conducted in CS GRA ITD on development of Electromechanical Actuator for FCS will be taken into account.

c) Iron Bird Core-Partner(s) detailed activities:

In the frame of WP 3.4 the Core-Partner(s) will be requested to perform the following main activities:

- Contribute to the definition of the requirements and of final architecture of the Iron bird demonstrator, to the identification of its main components, functions and operation.
- Design, development and manufacturing of specific infrastructure in order to:
 - strictly reproduce the A/C installation of the electrical power distribution in terms of relevant components, wiring bundles and routes as resulted from technological studies conducted in R-IADP WP 2.3.4: "Enhanced Electrical Power Distribution & Load Management" and according to prototype components/equipment expected to be received from Systems ITD WP 5.3 - Electrical Distribution Power Conversion & Distribution- "Innovative Power Network".
 - Strictly reproduce the A/C installation of E-LGS as resulted from technological studies conducted in R-IADP WP 2.3.2: "Electrical Landing Gear system" (Equipment expected to be manufactured and delivered by Core-Partner(s)).
 - Strictly reproduce the A/C installation of FCS (FCC, Actuators, surfaces,...) as resulted from technological studies conducted in R-IADP WP 2.4: "Innovative FCS" installing, when necessary, the real or modified A/C structure. The configuration shall keep into account also the demo flight configuration provided in para 2.2.1 (equipment expected to be manufactured and delivered by Core-Partner(s)).
 - Install Generators, Alternators, Power converters and relevant Control Unit reproducing the Electrical Power Generation network (ATA 24) of the regional aircraft. These equipment will be provided by Alenia or could be expected as deliverable of Systems ITD WP 5.1 & 5.2 - Electrical generation/Conversion - Non Propulsive Energy Generation". The list of equipment constituting the simulated ATA24 network will be produced during project development.

Note: Laboratory Drive Stands to drive the Electrical Generator is not requested since expected to be already available.

- Install “real” electrical loads eventually supplied by Clean Sky R-IADP and/or Systems ITD members/partners, together with their associated counter load system. The list of such equipment will be produced during project development.
- Install programmable load banks simulating A/C electrical loads in order complete the global A/C electrical system simulation. Detailed list will be produced during project development. Equipment expected to be provided by Alenia Aermacchi or by CfP/CfT.
- Implement a simplified A/C model into a simulation module capable to verify the behaviour in a simulated flight condition.
- To implement a provision for full flight simulator interconnection
- Implement realistic reproduction of situations that could occur in flight, such as:
 - aerodynamic loads, e.g.: by means of load cylinders on the iron bird’s control surfaces.
- Enable the simulation of faults in the hydraulics, electrics, flight control system, and actuators.
- Support the testing activities for Electrical Landing Gear, Electrical Power Distribution and Flight Control systems.
- Provide Hardware and software for test automation, acquisition, recording and monitoring functions and subsystem/interface simulation, specifically related to the integrated ATA24 network, electrical distribution, Landing Gear and Flight Control system tested architectures.
- Perform Iron Bird final assembly and commissioning.

The Core-Partner(s) will operate under Alenia Aermacchi leadership, e.g.: Alenia will manage the relevant WPs, coordinate relevant technical activities and will be in charge of providing technology design and integration requirements and finally managing activities for prototype equipment/sub-system integration and validation.

2.2.1. FCS demo flight configuration

Purpose

In the framework of activities of the CS2 Regional Aircraft IADP, the goal will be to implement and test on a flying demo, derived by a certified aircraft, Load Control/Load Alleviation functionalities.

So the Iron Bird will also be used to support Load Control/Load Alleviation (LC/LA) system design, inter-system integration activity, Verification and Certification processes; this to achieve the permit-to-fly to the demonstrator aircraft (FTB1) through use of a partial HW in the loop configuration.

Specifically Iron Bird will allow performing the following test activities:

- EMA performance test actuating real winglets in normal and degraded mode (failure injections) in no-loads conditions and with the aerodynamic loads simulated.
- Verifying that the LA/LC algorithm through winglet adjustment is able to alleviate the loads on the wing.
- Verifying that following winglet failures, the A/C controllability is marginally impacted.

Consequently the test activities will be performed submitting FCS System under Test (SuT) into a laboratory environment (FCS Iron Bird) simulating the Aircraft in flight. Only the activities relevant to FCS Iron Bird are part of the proposed activities for Core-Partners. The activities concerning SuT feasibility studies, development and demonstrator availability are supposed to be performed in System ITD framework.

➤ **FCS System under Test (SuT) (not object of this proposed activities)**

In order to perform the functionality of Load Control/Load Alleviation (LC/LA), it is foreseen the fitting of movable winglets into the wings of the demo A/C: from FCS point of view, this new configuration will cause impacts on a traditional FCS A/C architecture of the demo aircraft FTB#1.

The delta FCS System will be constituted by:

- A/C Sensors (Inertial and Air Data sensors) and/or dedicated and embedded Sensors (accelerometers, strain gauge and maybe an AoA sensor).
- Flight Control Computers (FCCs) with LC/LA control laws implemented.
- Electro-mechanical actuation system (EMA) integrated with deformable structure (movable winglet).

Consequently in Iron Bird this new delta configuration shall be suitably integrated.

➤ **FCS Iron Bird description (object of this proposed activities)**

The Core-Partner(s) shall develop and provide an integrated FCS Iron Bird that will be located in Alenia Aermacchi facility.

The FCS Iron Bird will be composed by the following main items:

- Skeleton (support structure)
- Winglet Load Control Modules
- Sensors Excitation.
- Electrical/Hydraulic Power Supply/Distribution
- Test Management Computing system

The structural skeleton will be able to accommodate A/C SuT installation (LH and RH winglets) as in the demo A/C as far as is possible. The actuators under test (EMA) shall be installed on a fixture on the skeleton simulating the real A/C environment in terms of stiffness reproducing the real winglet kinematics and using possibly real winglets (a representative model of winglet in terms of material,

size could be an alternative) with connection to the wing. The winglet shall be modified to accommodate mechanical links to Load Control.

Winglet Load Control Module will be able to simulate Aerodynamic Load to the winglets through dedicated distributed actuators controlled by a dedicate load simulation controller included in the Test Management Computing system.

Winglet Load Control Module can be hydraulically or electrically supplied.

Electrical/Hydraulic Power Supply/Distribution shall be foreseen to supply SuT (also in degraded condition) and Iron Bird facilities included the Load Control Module.

A/C sensors shall be implemented into Iron Bird and stimulated via Test Management Computing system.

Test Management Computing system shall consist of a Test Control Console and of a Simulation module.

The Test Control Console module shall permit to the user to interface with the test rig in order to set up and launch the tests, manage Data Acquisition and recording, manage Electrical and Hydraulic Power Supply interfaces, etc.

The Simulation module shall implement:

- the simulated items as the non-present LRIs (Air Data sensors , inertial sensors and accelerometers) and A/C external I/Fs missing (Avionics, etc),
- the management of the Aerodynamic Load and the Wing disturbance and sensor excitation model (if necessary),
- a simplified aero-elastic model of the A/C,
- ability to connect the Iron Bird directly with the full Flight Simulator.

➤ **FCS Iron Bird proposed activities**

The Core-Partner(s) shall be responsible to develop and provide an integrated FCS Iron Bird that will be located in Alenia Aermacchi facility according to the contents defined in above para “FCS Iron Bird Description”.

In detail the Core-Partner(s) will contribute to the requirement definition and shall be responsible of:

- Architecture Definition
- Performance analysis
- HW and SW development
- Integration
- Commissioning

The Iron Bird Preliminary Architecture is shown in the following figure 1.

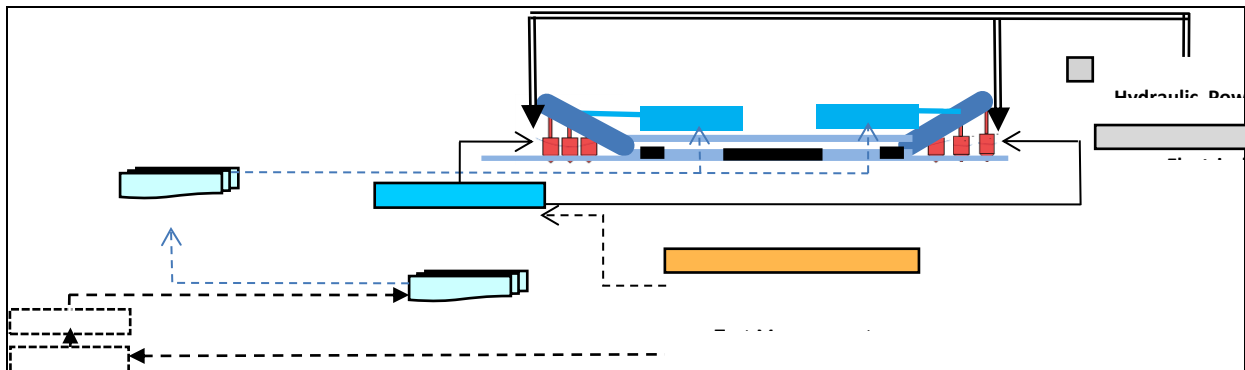


Fig. 1 - Iron Bird Architecture

▪ Intellectual Property

Section 3 of Clean Sky 2 JU " Multi-beneficiary model Grant Agreement for Members" shall apply.

Any activity/deliverable that will be produced by the selected Core-Partner(s), that will be developed starting from requirements, analysis, or inputs from the Leader Alenia Aermacchi shall be considered as jointly generated as per para 26.2 of said "MULTI-BENEFICIARY MODEL GRANT AGREEMENT FOR MEMBERS".

Joint ownership of results shall apply to the above described results.

3. Special skills, capabilities

The Core-Partner(s) shall have:

- Acknowledge competence in the management of very articulated programme and capability of technical conduction of complex project.
- Proven experience in international R&T projects cooperating with industrial partners, institutions, technology centres, universities.
- Quality and risk management capabilities demonstrated through applications on international R&T projects and/or industrial environment
- Proven experience in the use of design, analysis and configuration management tools of the aeronautical industry (i.e. CATIA v5 release 21, NASTRAN, VPM)
- Experience with TRL Reviews or equivalent technology readiness assessment techniques in research and manufacturing projects for aeronautical industry
- Acknowledge participation to industrial air vehicle developments with experience in “in-flight” components and laboratory set-up for aeronautical certification.
- Previous experience in development and design of advanced technologies in the field of Landing Gear system, Electromechanical Actuation for Landing Gear and Flight Control System.
- Proven experience in the design and development of innovative Large Scale Ground Demonstration SW and HW tools.

More specifically the applicant(s) organization expertise and skills are required for:

- Regional Aircraft class landing gear design, manufacturing and compliance with certification requirements.
- Electromechanical systems electrical actuation and power electronics applied to aeronautical systems.
- Electrical and mechanical installation and integration.
- Development of simulation models to be integrated in a flight simulator.
- Instrumentation data acquisition, recording and monitoring.
- Complex test Benches/Iron Bird Design and Manufacturing.

4. Major deliverables and schedule (estimate)

The applicant(s) shall provide deliverables for the following activities in accordance with the relevant Preliminary Schedules contained in the JTP V4 Chapter 7.

- E-LGS design and Development and Manufacturing for Iron Bird
- Electro mechanical Actuator for FCS for Iron Bird development and manufacturing
- Iron Bird Development
- Iron Bird Components Manufacturing
- Iron Bird Integration and final assembly
- Avionic functions and RFS simulation models development

Following table contains a preliminary list of the major deliverables.

Deliverables			
Ref. No.	Title - Description	Type	Due Date
D1	<i>E-LGS Design Document</i>	<i>Doc.</i>	<i>T0 + 14</i>
D2	<i>FCS Electro mechanical Actuation Preliminary Performance Analysis</i>	<i>Doc.</i>	<i>T0 + 14</i>
D3	<i>E-LGS Interface Control Document</i>	<i>Doc.</i>	<i>T0 + 26</i>
D4	<i>FCS Electro mechanical Actuation Interface Control Document + Design Document</i>	<i>Doc.</i>	<i>T0 + 26</i>
D5	<i>Avionic functions model</i>	<i>S/W</i>	<i>T0 + 38</i>
D6	<i>Simulation models for Regional Flight Simulator</i>	<i>S/W</i>	<i>T0 + 38</i>
D7	<i>Regional Iron Bird Description and Compliance Matrix</i>	<i>Doc</i>	<i>T0 + 20</i>
D8	<i>Iron Bird First Commissioning for Demo Flight Configuration</i>	<i>Doc</i>	<i>T0 + 48</i>
D9	<i>Regional Iron Bird Performance/Analysis and Verification matrix</i>	<i>Doc</i>	<i>T0 + 48</i>
D10	<i>Electrical Landing Gear Prototype system</i>	<i>H/W</i>	<i>T0 + 54</i>
D11	<i>Electro mechanical Actuator for FCS for Iron Bird</i>	<i>H/W</i>	<i>T0 + 42</i>
D12	<i>Iron Bird final assembly</i>	<i>H/W</i>	<i>T0 + 58</i>
D13	<i>Iron Bird Final Commissioning</i>	<i>Doc.</i>	<i>T0 + 60</i>
D14	<i>Final Report</i>	<i>Doc</i>	<i>T0 + 64</i>

Milestones WP2.4 (Flight Control System)			
Ref. No.	Title – Description	Type	Due Date
M1	Actuator Preliminary Design Review	Doc.	T0 + 14
M2	Actuator Critical Design Review	Doc.	T0 + 26
M3	Actuator Test Readiness Review	Doc.	T0 + 36
Milestones WP2.3.2 (Electrical Landing Gear)			
Ref. No.	Title – Description	Type	Due Date
M4	Landing Gear System Preliminary Design Review	Doc.	T0 + 15
M5	Electrical Landing Gear extension Retraction System Critical Design Review	Doc.	T0 + 28
M6	LGS for Iron Bird Readiness Review	Doc.	T0 + 53
Milestones WP3.4 (Iron Bird)			
Ref. No.	Title – Description	Type	Due Date
M7	Iron Bird Preliminary Design Review	Doc.	T0 + 14
M8	Iron Bird Critical Design Review	Doc.	T0 + 22
M9	Iron Bird Readiness Review for Demo Flight Configuration	Doc.	T0 + 45
M10	Iron Bird Readiness Review for Full Flight Configuration	Doc.	T0 + 59

5. Definition of terms

AC	Alternate Current	I/F	Interface
ATA	Air Transport Association	JTP	Joint Technical Proposal
A/C	Aircraft	LA	Load Alleviation
BPCU	Bus Power Control Unit	LC	Load Control
CfP	Call for Proposal	LH	Left
CfT	Call for Tender	LRI	Line Replaceable Item
CS2JU	Clean Sky 2 Joint Undertaking	OEM	Original Equipment Manufacturer
CS2	Clean Sky 2	REG	Regional IADP
EMA	Electro Mechanical Actuator	RFS	Regional Flight Simulator
EWIS	Electrical Wiring Interconnection System	RH	Right
E-LGS	Electrical Landing Gear System	R&T	Research and Technology
E2-EM	Enhanced Electrical Energy Management	R-IADP	Regional IADP
FCC	Flight Control Computer	SPD	Systems and Platforms Demonstrators
FCS	Flight Control System	SSPC	Solid State Power Contactor
FTB#1	Flight Test Bed 1	SuT	System under Test
GCU	Generator Control Unit	SW	Software
GRA	Green Regional Aircraft	TRL	Technological Readiness Level
H/W	Hardware	VDC	Voltage Direct Current
IADP	Integrated Aircraft Development Platform	WBS	Work Breakdown Structure
ITD	Integrated Technological Demonstrator		

II. Advanced Wing or Regional A/C - Technologies Development, Design and Manufacturing for FTB#1

Leader and Programme Area [SPD]	REG		
Work Packages (to which it refers in the JTP)	R-IADP WP 2.1 & 3.1		
Indicative Topic funding Value	6 M€		
Leading Company	Alenia Aermacchi S.p.A.		
Duration of the action	7 Years	Start Date	01/04/2015
Date of Issue	9 July 2014	Call Wave	1

Topic Number	Title		
JTI-CS2-CPW1-REG-01-02	Advanced Wing or Regional A/C - Technologies Development, Design and Manufacturing for FTB#1	Duration	7 Years
		Start Date	01/04/2015

Short description and terms of reference:

In the framework of Regional Aircraft IADP, the present topic is addressed to:

- develop innovative wing structure including the verification and validation of a new methodologies for the life cycle design at Aircraft level taking vantages from simulation of allowable, manufacturing processes, operative behaviour and load structure interaction; the methodology is proposed and developed in the frame of the regional aircraft; the life cycle methodology is applied to the automated manufacturing and testing of the relevant advanced composite components considering certification requirements and effect of defect issues;
- develop and mature Air Vehicle technologies related to an innovative adaptive wing for future regional aircraft; to perform Verifications and Validation of these technologies, through Wind Tunnel test, and building full scale mechanical and structural concepts mock up demonstrators for the developed devices concepts integrated into outer wing section.

From these technological development levels, innovative items shall be designed, manufactured and qualified for integration in the outboard wing section of the Flying Test Bed#1 for the final demonstration of TRL6. The main activities are under two main work packages:

- WP 2.1 ADAPTIVE ELECTRIC WING
- WP 3.1 AIR VEHICLE TECHNOLOGIES FTB#1

1. Background

In Clean Sky, a dedicated ITD - Green Regional Aircraft (GRA) - provides essential building blocks towards an air transport system that respects the environment, ensures safe and seamless mobility and builds industrial leadership in Europe. In Clean Sky 2, the Regional Aircraft IADP (R-IADP) will bring the integration of technologies to a further level of complexity and maturity than currently pursued in Clean Sky. Taking into account the outcomes of GRA and considering the high-level objectives derived from recent market analysis performed by the Leaders, the strategy is to integrate and validate, at aircraft level, advanced technologies for regional aircraft so as to drastically de-risk their integration on the following future products:

- Near/midterm (in-service from 2022-25on): Regional Aircraft with underwing mounted turboprop engines,
- Long term (enter in service beyond 2035): Breakthrough Regional Aircraft Configurations, e.g. a/c with rear fuselage mounted turboprop engines

In the R-IADP, the individual Technologies Developments for Regional A/C are arranged along with 8 “Waves” and several individual roadmaps which will be developed in synergy with other ITDs, in particular Airframe ITD and Systems ITD. The WBS for technologies development (WP2) within the R-IADP is the following:

- WP 2.1 ADAPTIVE ELECTRIC WING
- WP 2.2 REGIONAL AVIONICS
- WP 2.3 ENERGY OPTIMIZED REGIONAL AIRCRAFT
- WP 2.4 INNOVATIVE FCS

The high-level WBS of WP3 demonstration is the following:

- WP 3.1 AIR VEHICLE TECHNOLOGIES FTB#1
- WP 3.2 FUSELAGE / CABIN INTEGRATED GROUND DEMO
- WP 3.3 FLIGHT SIMULATOR
- WP 3.4 IRON BIRD
- WP 3.5 INTEGRATED TECHNOLOGIES DEMONSTRATOR FTB#2

This topic will address only activities relevant to WP's 2.1 and 3.1 so as to contribute to achieve the in-flight validation/demonstration, through the Flying Test Bed #1 (FTB#1), of a meaningful set of advanced wing technologies for regional A/C. Therefore, the selected Core-Partner(s) shall carry out strategic activities of the R-IADP project, e.g. the development of major items to be integrated on the FTB#1 demonstrator (from the initial studies, through the relevant technologies development/maturation, up to the manufacturing and qualification of such items as well as the support for their final integration on the demonstrator). In particular, the selected Core-Partner(s) will:

- perform the activities of the R-IADP WPs 2.1.x assuming a leading role together with Alenia Aermacchi within these work packages

- contribute to the activities of R-IADP WP 3.1.3 and WP 3.1.4
- participate to the WP Management Committees of R-IADP WP 2 “Technologies Development” and WP 3 “Demonstrations”
- contribute to the WP 0 “Management”, participating to R-IADP Steering Committee and Consortium Management Committee and assuming full responsibility of the risk management associated to their deliverables

The starting point for the technical work to be performed in each of the sub-work packages listed above will be the development of relevant technologies achieved in the current Clean Sky GRA ITD. These technologies will be further developed with the aim to achieve much higher integration and validation levels. Other technologies, including the ones from FP7, H2020 L2 projects and National Projects will be considered as well. For each sub-work package, specifics and dedicated periods of review, development and technology down selection for all demonstrators will be performed so that the selected technologies will be the ones than can really achieve the necessary TRL level in time for the ground and flight test demonstrations. The activities performed in these work packages have the main scope to take technologies for which there is a very high-level of confidence in achieving a satisfactory level of maturity under Clean Sky 2 so as to be integrated together with other interfacing technologies on the large-scale demonstrators of the R-IADP. For the Flight Demonstration Programme, the Flying Test Bed #1 is foreseen to be a modified existing a/c, TP engine under wing mounted. The technologies-concepts developed in the frame of Clean Sky 1– GRA ITD and SARISTU (VII UE Framework) projects need to be scaled on this new wing configuration and assessed in detail in order to provide the needed steps to improve TRL up to level 5 for this A/C configuration.

2. Scope of work

In the following paragraphs a general complete description of each WP is reported. Work Area Leader has the high level responsibility of these activities.

A dedicated following paragraph collects the Core-Partner(s) dedicated activity, to be considered under its own responsibility. In the following the description of the main topics area related to WP2.1

▪ Innovative Wing Structure D&M (Design & Manufacturing) - WP2.1.1

This work package is devoted to the Verification and Validation of the ground and flying demonstrator to minimise the life cycle design at Aircraft level. Development of advanced architectures to be adopted for wing structural design, structural sizing, SHM/NDI system, material processes and allowable assessment structural certification (FHA PSSA should be included) and assembly constraints have to be considered. Vulnerability and thermal analysis will be also considered. In service loads and service damages have to be monitored in order to achieve low operative costs. Key technology for these architectures will be composite/hybrid structures relying upon compliant technology. A correlated and necessary technology that shall be also developed is the SHM system at full scale level and relevant electronic control. Current projects (Clean Sky - GRA

and SARISTU) will provide technology maturation (TRL 4/5) for the structural-mechanics SHM and materials aspects, including full-scale limited experimental validations. The adoption of self-sensing control components and their validation in an operational environment through fly testing therefore represent a step forward, looking at potential application of such technology to innovative green airliners. This work package will be also addressed to the developments, verification and optimization of the liquid resin infusion technology for stiffened panels manufacturing so as to allow its application in the production of parts with a quality and performance standards suitable for in-flight real-scale demonstrations. Such work will be performed in close coordination with the Eco-Design transversal activities so as to optimize the Liquid Resin Infusion (LRI) process for a green "econolomic" fabrication of Regional AC wing stiffened panels by low (Out of Autoclave - OoA) energy curing. The expected benefits that will be addressed from the introduction of the liquid infusion technology for the manufacturing of the composite stiffened panels of the wing box consist in the reduction of the manufacturing costs, in the improvement of automated manufacturing processes and in the improvement of the environmental aspects if compared to a traditional pre-preg lamination process. Other aspects dealing with structural enhancements due to thermoplastic use could be implemented if appropriate level of TRL is reached. The work package will be also devoted to the developments, verification and optimization of suitable advanced technologies & materials for the manufacturing of the wing box components as ribs, spars, clips, etc., aimed to the reduction of the manufacturing costs and the improvement of the environmental aspects if compared to a traditional process. The present work package will also be addressed to the development of an high automated process for the assembling of the Wing Box components in order to achieve a significant reduction of the manufacturing costs and timing. Present technology shall provide impact to the 2025 A/C and beyond.

- Morphing Structures - WP2.1.2

Development of advanced architectures to be adopted as wing control surfaces (small trailing edge devices / adaptive winglet / droop nose) for loads control function in order to achieve lighter and simplified actuation/kinematic systems. Key technology for these architectures will be morphing structures relying upon compliant structures and mechanisms. A correlated and necessary technology that shall be also developed is the actuation system and relevant electronic control. Current projects (Clean Sky - GRA and SARISTU) will provide technology maturation (TRL 4/5) for the structural-mechanics and materials aspects, including full-scale limited experimental validations. The adoption of morphing control surfaces and their validation in an operational environment through fly testing therefore represent a step forward, looking at potential application of such technology to innovative green airliners. These technologies are supporting both 2025 A/C and 2035 A/C depending upon the concepts complexity. Small morphing elements like winglet or morphing tabs shall be installed on 2025 A/C, while more complex larger devices, like seamless droop nose taken in combination with Natural Laminar Flow wing, shall support 2035 A/C and beyond.

- Advanced HLD (High Lift Devices) - WP2.1.3

Developing advanced highly-efficient HLD considering especially architectures suitable for a NLF wing, in order to increase A/C high-lift performances in take-off and approach/landing conditions. The achievements from Clean Sky - GRA ITD (TRL 4/5) will form the basis for the concerned further development of HLD technologies. Droop nose coupled with flap will be the HLD concepts considered, as alternative solutions to conventional leading edge and trailing edge systems. Such architectures will be especially taken into account for application to a NLF outboard wing designed for a future TP regional A/C. An important aspect that shall be also considered is the actuation system and the relevant electronic control. As state above, this technology shall support the 2035 A/C.

- Load Control & Alleviation (LC&A) - WP2.1.4

Development of Load Control & Alleviation (LC&A) technologies for dual purpose:

- i. to optimise spanwise load distribution (LC function) so as to improve aerodynamic efficiency in all flight conditions
- ii. to avoid that wing bending and torsion moment from gust and/or manoeuvre loads may exceed given limits (LA function), thus optimising the wing structural design for weight savings.

The work shall include the following elements:

- Conceptual aero-mechanical design (sizing and settings) of conventional (used in unconventional way) / unconventional devices for loads control (small TED, morphing trailing edge sections, morphing winglet) and load alleviation (innovative wing tip).
- Conceptual design of control laws, design and structural integration of respective actuation system, considering system enhancements to cope, in larger and better extent, with dynamic load and aeroelastic effects.

The results of technological studies, validated by WT tests on large scale aero-elastic and aero-servo-elastic wing models, round control system testing carried out in the frame of Clean Sky – GRA ITD project will represent the key elements for further development of the technical solutions for LC&A functions and their future application to green regional aircraft. These results shall be extended by means of further aerodynamic, aero-elastic, structural analysis and relevant ground experimental validations dedicated to scaling the developed concepts to the selected CS2 FTB#1 configuration and to define the relevant performances level. These concepts shall support the 2025 A/C developments with the exception of those concepts considering the aeroelastic coupling of wing flexibility with active devices for load alleviation purposes that shall support 2035 A/C configurations.

- Wing NLF (Natural Laminar Flow) - WP2.1.5

Aerodynamic design of a Natural Laminar Flow (NLF) wing tailored to a future Turbo-Prop Green Regional A/C to reduce drag / enhance aerodynamic efficiency at cruise conditions will contribute to reduce A/C fuel consumption / gaseous emission. NLF is a mature technology which proved, from several flight tests in the past, to be able of providing large reduction (up to 10%) in the A/C drag. Development of a NLF wing design sized to a TP regional A/C represents a breakthrough toward next-

generation green air transport. By taking into account the presence of wing-mounted propeller engines, only the outboard panel of the wing will be designed to be laminar; this part (from the kink/nacelle station to the wing tip) is, however, a large portion of the total wing surface. Achievements / lessons learned from theoretical and experimental activities carried out in this field in the frame of Clean Sky GRA IADP programme, namely design and WTT validation of a NLF wing for a future 130-seat rear engine regional A/C, will be the basic know-how for the concerned technology development for 2035 A/C and beyond.

▪ Drag Reduction - WP2.1.6

Development of innovative devices for turbulent skin friction drag reduction in all flight conditions, and innovative coatings to avoid contamination issues on laminar wings, therefore preserving low-drag performance at cruise design point. Innovative aerodynamic concepts (say 3D-riblets) and new manufacturing techniques will be exploited, by evolution of results from Clean Sky GRA ITD, in order to realize advanced riblets films to be applied to the A/C external surface. These concepts development shall support 2025 A/C. Following table summarizes, for each mentioned concept to be developed in WP2.1 and tested in WP 3.1, the foresee technology challenges and which demonstration shall be performed. Column describing the Technology Demonstrators is also indicating who is the responsible of the demonstrator production: WAL (Work Area Leader) and CP (Core-Partner(s)).

COMPONENT	TECHNOLOGY CHALLENGES	TECHNOLOGY DEMONSTRATORS
OAD	A/C Integration of different complementary technology concepts for aerodynamic efficiency, loads control and alleviation (LC&A), Natural Laminar Flow wing, advanced HLD, Drag reduction.	Large scale WTT demonstration of the integration of all the new wing concept FTB#1: overall A/C performances in any A/C configuration for all flight phases for LC&A, Drag Reduction, Handling Qualities. Responsibility: Work Area Leader (WAL)
NATURAL LAMINAR FLOW WING	Integration on Regional TP configuration of Outer Wing section based on Natural Laminar Flow profiles increasing cruise and climb wing aerodynamic performances of A/C configuration.	Large scale WTT demonstration of NLF concept for TP configuration Responsibility: CP
DROOP NOSE	Seamless morphing leading edge section to improve high lift, low speeds, Natural Laminar Flow wing aerodynamic performances of TP configuration.	Large scale WTT demonstration of HLD concept for TP configuration Responsibility: CP

COMPONENT	TECHNOLOGY CHALLENGES	TECHNOLOGY DEMONSTRATORS
TE FLAP	Multi-functional trailing edge Flap with a subcomponent (based on morphing structures), for operation with flap retracted, able to operate in continuous setting to improve A/C high speed performances.	Large scale WTT demonstration of flap concepts Full scale structural-mechanical functional ground demonstrators Responsibility: CP
WINGLET	Winglet with full morphing characteristics for larger drag reduction for cruise and climb flight phases.	Large scale WTT demonstration of winglet concept Full scale structural-mechanical-systems functional demonstrator • FTB#1: 1 specimen for “on – ground” static and functional tests. (RH winglet section). • FTB#1: 2 specimens (LH and RH winglet sections) ready for flight Responsibility: CP
NEW WING TIP DEVICES	Wing tip devices to perform effective loads alleviation on TP configuration	WTT demonstration of wing tip concept Full scale structural-mechanical-systems functional demonstrator of TP configuration • FTB#1: 1 specimen for “on – ground” static and functional tests. (RH wing section). • FTB#1: 2 specimens (LH and RH wing sections) ready for flight Responsibility: CP
OUTER WING SECTION (*)	Modification of current structural composite components design technologies to incorporate: - Top panel: optical fiber for damage detection, innovative network/component architecture, - Lower panel: innovative hybrid technology for damage detection using optical fiber as sensor of strain and lamb waves, - Front and Rear spars: innovative internal load monitoring using	• FTB#1: 1 specimen for “on – ground” static and functional tests. (RH outer wing section). • FTB#1: 2 specimens (LH and RH outer wing sections) ready for flight Responsibility: CP

COMPONENT	TECHNOLOGY CHALLENGES	TECHNOLOGY DEMONSTRATORS
	optical fiber, - Wing Box: innovative external load monitoring network, using optical fiber, - New Materials, Design and Manufacturing technologies - Winglet morphing: shape control using optical fiber - Natural Laminar Flow external surfaces requirements	

(*) from engine section to wing tip

Work requested to Applicant (Core-Partner(s) responsibility) for WP 2.1

Concepts/architectures/technologies developed in the frame of Clean Sky 1– GRA ITD and SARISTU (VII UE Framework) projects (TRL 4/5) for an outer wing portion of new a turbo prop regional aircraft shall be the base of the wing design. Applicant shall develop and validate the relevant engineering solutions performing aerodynamic, loads and aero-elastic, structural and mechanical items design, structural and mechanical items manufacturing, health monitoring and relevant ground experimental validations for the new turboprop aircraft configuration, selected by R-IADP in WP 1. For particular aspects Applicant is authorized to use Calls for Proposal and Calls for Tender to complete the tasks, see below for details. Relevant sizing of activities budget shall take into account this opportunity. In the following paragraphs each WP 2.1 task under responsibility of CP has been described.

▪ Innovative Wing Structure D&M (Design & Manufacturing) - WP2.1.1

The scope of the present work package is to develop an advanced methodology for the service life management verified and validated through experimental tests and results correlation.

The activities to be performed can be divided into the following tasks:

- Task 1: Service life management
- Task 2: Manufacturing & testing for Verification and Validation

a) Task 1 – Service life management

From design point of view design concepts shall be defined ranging from global to detailed design properly addressing lead time reduction also suggested methodology from TRL 3. Verification and Validation concepts have to be clearly identified to be driven for work flow and activity development. The Applicant has to identify proper life cycle design parameters to be applied for high performance self-sensing composite wing. Structural sizing, failure mode prediction capabilities; defects and residual stress have to be considered for structural quality assessment. Building block approach

simulation should drive real tests for certification. Furthermore the Applicant has to identify the appropriate technology quality assessment from manufacturing to aircraft performance control through assembly and monitoring technology. Design constraints have to be properly considered for a TRL6 usage (real environmental constrain considered); reliability and robustness has to be properly addressed. For example multi-objective gradient-based optimization techniques and/or hybrid form with genetic algorithms algorithm can be considered. From technological point of view Structural / system concept architectural solutions for self-sensing control system, selection of sensors and actuators for load and damage control shall be identified. Control system and concepts actuation functionality shall be installed in the same full scale concepts prototypes ground test wing box; ground test (functional test) has to be properly identified in order to verify mechanical requirements of the structural component properly sized to provide the appropriate maintenance strategy. The maintenance strategy has to be fixed at design stage on the above mentioned specifications (design platform). The multidisciplinary validation performed by the Applicant, shall constitute input for the first down selection phase of concepts by IADP. The winner concepts from this down selection have to be verified in to the full scale fuselage ground test. The concepts passing this second technologies selection (Fuselage full scale test) shall be then scaled on IADP demonstrator configuration and the following evaluation shall be the input for the final gate to reach TRL 6. The Applicant has to show an appropriate TRL grow up strategy from the initial TRL 2, through TRL 3 TRL 4 and finally TRL6. Two different sources of technology have to be considered depending upon readiness level: from IADP for TRL2 and from ITD (JTI GRA 1 and SARISTU) for TRL 3/4. Validations results shall be analysed in the final down selection phase for flight test.

b) Task 2 - Manufacturing & testing for Verification and Validation

The aim of the present Task is the verification of the numerical methods developed in the previous Task and the validation by numerical - experimental results correlation. Materials will be preliminary investigated by the Applicant between few selected options (on the basis of limited mechanical/physical-chemical tests), up to final selection for each main component (stiffened panels, ribs, spars, miscellaneous parts). For stiffened panels, the liquid resin infusion manufacturing process executed out of autoclave (without pressure) shall be investigated using dry fibres for automatic placement technique and a cure cycle optimized to reduce the energetic consumption. The relevant technology shall be addressed to a reduction of the manufacturing costs and to an improvement of the environmental aspects, if compared to a traditional pre-preg lamination process. For the further wing box components, the following technologies shall be investigated:

- Spar: prepreg automatic fibres placement technology (or liquid infusion process executed out of autoclave),
- Rib: advanced low cost process (out of autoclave, thermoplastic, HC, etc.),
- Clit: advanced low cost process (out of autoclave, thermoplastic, etc.),
- Miscellanea: advanced low cost process (out of autoclave, thermoplastic, etc.).

Also for these components, the development of advanced technologies for manufacturing is aimed to the reduction of the manufacturing costs and the improvement of the environmental aspects if compared to traditional processes. The selected processes for each component shall be developed

and assessed through dedicated manufacturing trials to be characterized in order to verify part quality repeatability. The work package will include also the development of repair solutions for material / technologies selected, in particular:

- 1) temporary and removable repair solutions,
- 2) repair solutions suitable during production,
- 3) repair solutions for maintenance.

An appropriate Test Plan following the building block approach covering the coupon, element and sub-component levels will be defined by the Applicant. Technologies, materials, processes for manufacturing of coupons, elements, sub-components will be representative of the structural configuration to be adopted for different components of the new regional aircraft wing box: stiffened panels, spars, ribs, clips. According to the Test Plan, each selected material shall be characterized by means of standard tests performed on coupons for Level 1. Structural details representative of stiffened panels, spars, ribs and miscellaneous will represent the items to be designed, manufactured and tested for Level 2. Only spars, ribs sub-components will be designed, manufactured and tested for Level 3. According to an innovative wing self-sensing structure design, for each Level, all items shall be monitored not only by traditional sensors but also through the use of harvesting sensors, optical fibers, wireless and wired Structural Health Monitoring system, NDI systems, sensors for humidity detection/control, etc. All experimental results shall be included in respective Test Reports. The numerical activities shall be aimed to the Verification of the developed integrated methodology in terms of accuracy of relevant of predictions. Furthermore, the correctness of the test model of the full test set-ups for different levels shall be validated through the numerical-experimental correlation performed using the available tests results.

▪ Adaptive Wing Concepts Technology Maturation (WP's 2.1.2, 2.1.3, 2.1.4, 2.1.5, 2.1.6)

Applicant shall investigate the aero-mechanical and aero-structural performance level of WP2.1 technology concepts for the CS2 A/C configuration. The activities shall be focused to provide the needed information and validations to perform the technologies down selection phases. These selection steps are requested to highlight the concepts to be finally designed, manufactured and tested in flight on FTB#1. Starting TRL shall be 3/4 for this A/C configuration and shall be increased up to TRL 5 in the work package 2.1 as an input for flight tests preparation. So, the short-medium term objectives/milestones shall include down selections activities to be performed by the Applicant that shall organise these assessments in three main phases:

a) Wing devices aerodynamic, aero-mechanical design and validation

Computational loads driven optimisation of integrated wing (structure and systems) aerodynamics enhancements and LC&A features to define requirements and solutions to meet wing loading and aerodynamic performance optimality criteria in the flight envelope key points and minimize weight. Optimization process results shall be validated by mean of proper large scale Wind Tunnel Test campaign to be organized and performed in order to verify the aerodynamic and loads performance levels of the evaluated wing devices. Applicant shall prepare the Wind Tunnel tests and models

requirements while Wind Tunnel tests execution shall be performed by mean of Calls for Tender, so they shall not be considered part of this Call application.

b) Wing devices structural design and validation

Structural and mechanical concepts analysis to define substructures for wing sections and movables following aero-mechanical requirements defined in point a). Structural and mechanical solutions for devices shall be proven by mean of full scale concepts prototypes manufactured and ground tested in order to verify strength and weight levels.

c) Wing modification, including actuation system and control architecture.

Aerodynamic devices (NLF sections, drag reduction devices) shall be defined in sufficient detail in order to allow flight verification within WP3. Architectural design of control system, conceptual definition of load measurement strategy and actuation system for load control & management following actuation logics requirements defined into a). Control system and concepts actuation functionality shall be installed in the same full scale concepts prototypes of point b) and ground tested (functional test to be verified in Iron Bird) in order to verify mechanical requirements defined in point a) and b) and validate the multidisciplinary design of concepts.

Aero-mechanical and structural design assessments, performed by the Applicant, shall constitute input for the first down selection phase of concepts from previous research projects, performed by the R-IADP Leader. The winner concepts from this down selection shall be validated by Wind Tunnel, ground structural, control and actuation functional tests described in above points. These validations results shall be analysed in the final down selection phase for flight test. The concepts passing this second technologies selection shall be then scaled on FTB#1 configuration and the following evaluation shall be the input for the final gate to reach TRL5. This last activity and the concepts-technologies down selections using results from above sub tasks shall be performed by R-IADP Leader. In the following a general complete description of WP 3.1 is reported. Work Area Leader (WAL) has the high level responsibility of this activity. Following the CP (Core-Partner(s)) dedicated activity, under its own responsibility, is described.

▪ WP3.1 Air vehicle Technologies Demonstrator - Flying Test Bed #1 (FTB1)

Stepping back to scope of work, main objective of this demonstrator is the integration and flight-testing of innovative technologies for a new generation wing and advanced flight control systems. Innovative wing related systems and wing structural solution will also be incorporated as feasible and possible. Aerodynamics enhancements and LC&A features will be demonstrated in-flight such as: outboard wing featuring laminar airfoils for skin friction reduction; high A/R by means of adaptive/innovative winglets, active loads control system architecture (sensors, control laws, actuators), etc. From structural point of view main objective of demonstration is the integration and flight-testing of innovative technologies for a new generation wing and advanced self-sensing ability. Innovative materials for wing box structural architectures, systems and wing integrated structural solutions will be incorporated as feasible and possible. External/internal load control features like inverse load methodology (from internal load monitoring to external load evaluation) will be

demonstrated in-flight, validated for TRL6. This demonstrator will be used to perform in-flight damage detection that will include vulnerability load identification and thermal/humidity/lightening validation. This has to be done for in flight damage detection and on ground damage management for Structural Health Management once that Structural Health Monitoring has been assessed at level of full scale test. Furthermore, this demonstrator will be used to perform in-flight investigation and development of innovative technologies regarding on-board systems, cabin passengers/crew comfort and equipment life. Based upon results of technologies development, a suitable set of requirements for ground and in-flight demonstrations will be produced by R-IADP Leader. Test requirements will be used by R-IADP Leader to define a well detailed test plan and to identify two sets of test specifications: one for full scale outer wing section ground tests addressed to permit to flight achievement and the other for the flight demonstration for FTB#1: complementarities and synergies shall be ensured between the two full scale wing boxes. In particular, an existing aircraft, turboprop engine underwing mounted, will be selected to be used as Flying Test Bed for this WP (FTB#1). The choice will reflect the adequacy of the existing aircraft to represent with appropriate modifications the configuration of the innovative air vehicle technologies to be validated. On basis of current assumptions, most of the technologies could be demonstrated by means of appropriate modifications introduced mainly to the outboard part of the wing and in the fuselage. With this demonstrator the target TRL is 6 for a meaningful set of technologies that will be selected from the following ones will be validated in-flight as preliminarily indicated hereafter. A detailed qualification program plan (QPP) for Permit to Fly shall be prepared by R_IADP Leader in order to define the main steps and methodologies to get this goal.

a) AERODYNAMICS

- Natural Laminar Flow Wing: test A/C outboard wing featuring laminar airfoils for skin friction drag reduction.
- Winglets: Test A/C wing equipped with innovative (blended, spiroid, split tip type) fixed and/or movable/adaptive winglet for induced drag reduction in climb and cruise flight conditions, and for load control / passive load alleviation.
- Passive Aerodynamic Solutions: Innovative 3D riblets for turbulent skin friction reduction and innovative coatings for low drag and/or anti-contamination purposes to be applied to both (turbulent region of laminar) wing and fuselage surfaces

b) LOADS CONTROL & ALLEVIATION

- Wing Active LC&A: In flight validation of a control system architecture (wing devices, sensors, loads estimators actuators, control laws) for load control (optimized span loads distribution to maximize efficiency in all flight conditions) and load alleviation (to avoid that wing bending and torsion moments from gust and manoeuvre loads may exceed given limits). Definition of relevant Control Laws (in synergy with S&C) and in flight validation of performances of conventional / unconventional wing control movables for load control (adaptive winglet) and load alleviation (innovative wing tip devices) under wing dynamic response to steady and unsteady conditions.

- Passive Loads Alleviation: In flight validation of passive "compliant" structures winglet concept for wing loads alleviation.

c) STABILITY and CONTROL (S&C)

- Investigate handling quality of a more after CoG A/C configuration and design the appropriate Control Law modification, also integrating LC&A modules, to be tested in flight

d) STRUCTURAL DYNAMICS AND VIBRATIONS CONTROL

- Advanced Vibration Monitoring: In-flight concept demonstration and model validation
- Advanced Dynamic Monitoring: In-flight concept demonstration and model validation
- Cabin Floor Comfort Optimization: In-flight comfort model validation and concept demonstration.

e) STRUCTURES

Innovative wing: test a/c outboard composite wing box made of advanced materials and manufactured through new production processes (e.g. liquid infusion stiffened panels, advanced process for wing box components manufacturing, high automated process for wing box assembling, etc.). The wing external shape and sheet refinement will be compliant with demanding requirements of laminar wings in terms of tolerance to surface irregularities (steps/gaps, isolated roughness, waviness). The innovative wing design will include wing self-sensing structure (harvesting sensors, optical fiber, wireless, wires Health Monitoring, humidity detection/control, etc.) low life cycle cost methodology, innovative structural test full scale simulation.

f) SYSTEMS

Integration within completely new wing architecture of advanced systems for advanced functionalities like morphing aerostructures and load controls/alleviation devices.

g) FLIGHT CONTROL SYSTEM

Considering the architecture of the innovative FCS and the basic demo A/C configuration, suitable selections of FCS functionalities/subsystem subset, to be implemented into FTB#1, shall be performed; This selection shall keep into account the needs to maintain a good representation of new architecture, to meet budget constraints and not to jeopardize meaningfully the current A/C certification. In order to perform an effective devices control and actuation system validation an innovative Iron Bird developed in synergy with present wing devices structural and mechanical items is foreseen in WP 3.4.

h) FLIGHT DEMONSTRATOR INTEGRATION

Flight demonstrator FTB#1 new devices, including relevant sub systems shall be designed, manufactured and tested during WP3.1 tasks. These sub assembled items including structures, systems, sensors, shall be integrated into the FTB#1 by R-IADP Leader. The qualification documentation at subsystem level, relevant to concepts and devices developed by Task under

responsibility of CP, shall be provided to R-IADP Leader by CP following the requirements of the qualification program plan (QPP). Each concepts development process shall be demonstrated by mean of a Preliminary and a Critical Design Review, at subsystem level, under responsibility of CP. A Preliminary Design Review at A/C level shall be done in order to verify the adequacy of all the design documentation relevant to the FTB#1 with respect to design and safety requirements. Full assembly item qualification test for Permit to Fly shall be then performed by R-IADP, as well preparation of all the documentation at A/C level for the in-flight qualification. A/C level qualification test shall be performed under responsibility of R-IADP Leader. A Critical Design Review shall be performed in order to verify the correct conclusion of integration phase and the A/C (FTB#1) System readiness to start the flight demonstration phase.

i) FLIGHT DEMONSTRATION

On the basis of the technology demonstration requirements and of QPP, R-IADP shall define a Flight Test Plan. Prepare and submit to EASA Authority the Permit to Fly documentation for negotiation and approval. Having Permit to Fly, R-IADP shall organize and perform the demonstration flight tests. Flight test results shall be post processed and used to generate the final report to the Project with the contribution of all the partner including CP.

Work requested to Applicant (Core-Partner(s)) for WP 3.1

In the following paragraphs each WP 3.1 task under responsibility of Core-Partner(s) has been described. In order to mitigate the technical/schedule/cost risks associated to the very complex and ambitious demonstration goals and to effectively contribute to the success of the in-flight demonstration programme for regional aircraft, the Applicant shall develop a simulated outer wing demonstrator as well as the real demonstrator, this last to be tested in flight. Innovative materials for wing box structural architectures, systems and wing integrated structural solutions will be incorporated by the Applicant as feasible and possible. The first demonstrator is fully simulated for structural loads application and structural failure modes in order to determine the structural ultimate load and damage/load detection reliability/probability for certification: this has to be done for all the possible load conditions. The second outer wing demonstrator, the real one in flight condition, has to be done for validation on the base of the above defined requirements. The simulated test has to be done to verify the same requirements as the real. On basis of current assumptions, most of the technologies could be demonstrated by means of appropriate modifications introduced mainly to the outboard part of the wing. At the end of each component design phase, Core-Partner(s) shall organize a Preliminary Design review, at subsystem level, so to verify the correct design approach toward the design requirements. In detail, Applicant shall provide production design and manufacturing of sub structures (spars, ribs, cleats and miscellanea) for an outer wing box demonstrator. Applicant shall consider modifications to an existing flying test bed to accommodate new sub structures. New item concept design, requirements and specifications shall be provided by the R-IADP.

In particular:

- the Applicant shall provide the design and manufacturing of the complete set of spars,

ribs, and miscellanea for realization of a full scale wing box to be tested on ground, the Applicant shall provide also the design and manufacturing of the complete set of spars, ribs and miscellanea for realization of a full scale wing box to be tested in-flight.

- The fabrication of the above mentioned spars and ribs shall be preceded by
- manufacturing of a representative item for each family to be destructively characterized.

For what regarding adaptive wing new devices final demonstration, Applicant shall scale up on FTB#1 configuration the adaptive wing concepts developed in technologies maturation phase (WP 2.1.2, 2.1.3, 2.1.4, 2.1.5, 2.1.6) and selected for flight demonstration by the WP 2.1 down selection phases. Applicant shall provide design, manufacturing and assembly of wing structures and mechanisms (new items or modified parts) for aerodynamic solutions and new actuation control system to be installed on the flight demonstrator. Applicant shall consider modifications to flying test bed (FTB#1) configuration to accommodate new systems. New item concept design, requirements and specifications shall be provided by the R-IADP.

Applicant shall organize the work in the following phases:

a) Structural design of new systems

Engineering design of new wing fixed and movable parts (conventional and non-conventional surfaces) and related sub-structures for flight demonstrator. These, pending on the relevant selected solutions (WP 2.1.x), might include following components (new and/or modified parts of existing items):

- New winglet fixed and morphing, new wing tip devices.

Inputs:

- Structural/mechanical conceptual solutions of new wing control movables, relevant mechanisms for flight demonstrator (output of WP 2.1.x)

Outputs:

- Structural/mechanical drawings for manufacturing of new wing control movables and relevant mechanisms for flight demonstrator
- Drawings for installation of the above items on the flight demonstrator

b) Production of new structural systems

Manufacturing of new wing movables (conventional and non-conventional surfaces and related sub-structures for flight demonstrator, designed at previous stage. These might include following components (new and/or modified parts of existing items): All-movable winglet or winglet morphing. These new wing movables shall be provided also to Iron Bird (WP 3.4) to be adapted and to perform an overall integration between System and Structure

c) Installation of actuation and control system

Installation of embedded actuation and sensors (from WP 3.4) into LC&A structural items and perform structural, functional and Ground Vibration Tests.

At the end of manufacturing, assembly and subsystem testing phases of devices, Core-Partner(s) shall perform a Critical Design Review to verify the readiness of developed system to be released for integration into FTB#1. With this outer wing flying demonstrator the target TRL is 6 for a meaningful set of technologies that will be selected and validated in-flight. All previous tasks shall provide key elements for assembly ground and flight demonstrator (FTB#1) outer wing section. Integration of outer wing section of flying demonstrator shall be performed under the responsibility of WAL but having as input, assembled and qualified for permit to fly purposes, designed and manufactured items from previous tasks. Therefore Core-Partner(s) shall pay particular attention, assuring and demonstrating the proper level of quality assurance for design, manufacturing, and subsystem testing procedures of all above wing items. The quality level shall be demonstrated appropriate for aeronautical industry. For particular aspects Applicant is authorized to use Calls for Proposal and Calls for Tender to complete the tasks. Relevant sizing of activities budget shall take into account this opportunity.

3. Intellectual Property

SECTION 3 of Clean Sky 2 JU "Multi-Beneficiary Model Grant Agreement For Members" shall apply. Any activity/deliverable that will be produced by the Core-Partner(s), that will be developed starting from requirements, analysis, or inputs from Alenia Aermacchi shall be considered as jointly generated as per para 26.2 of said MULTI-BENEFICIARY MODEL GRANT AGREEMENT FOR MEMBERS. Joint ownership of results shall apply to the above described results.

4. Confidentiality

Article 36 of Clean Sky 2 JU "Multi-Beneficiary Model Grant Agreement For Members" shall apply.

5. Special skills, capabilities

Following skills and capabilities are required to Applicant:

- Acknowledge competence in the management of very articulated programme and capability of technical conduction of complex project.
- Proven experience in international R&T projects cooperating with industrial partners, institutions, technology centres, universities.
- Quality and risk management capabilities demonstrated through applications on international R&T projects and/or industrial environment
- SHM: wide expertise in SHM/structural analysis and aircraft life cycle management with emphasis on damage, impact, wave propagation.
- Adaptive wing integration: wide expertise in System Engineering of processes for adaptive wing technologies integration.
- Acknowledge competence in numerical multidisciplinary optimization.
- Stress Analyst SHM: Group of internationally leading, large-scale structural analysis,
- Proven experience in manufacturing of substructures in form of large (2 m x 2 m) aeronautical stiffened composite panels and manufacturing electronic SHM systems.
- Proven experience in building full-scale SHM systems for fuselage, wing.
- Proven experience in non-destructive inspections.
- Acknowledge experience in regional A/C class certification for several aspects (Structures, Sub systems, Flight Controls) and setting up inspection schemes.
- Advanced Aerostructural computational: Partners with long experience in tools for 3D aerodynamic (CFD), aeroelastic/structural analyses (CFD/CSM coupling), control law design and simulation is regarded as a paramount requirement to correctly address the physical phenomena involved.
- Wind Tunnel Model Specifications: Partner with large experience in defining requirements for designing and manufacturing of wind tunnel models (Static and aeroelastic) for aeronautical applications
- Structural items Design and Manufacturing: Partner with wide experience in designing, manufacturing and assembling of full scale complex large structural items both in metal and carbon fiber material for aeronautical applications, certified by EASA CS 25 rules.
- Extensive CAE Modelling: Partner with large experience in CAE modelling and analysis, CATIA.V5, Matlab, finite element complex modelling, non-linear multibody modelling, engineering process modelling and simulation data management.
- Ground Tests: Partner with: i) good experience in Ground Vibration and full scale components, including availability of a reliable test layout (accelerometers, strain gauges, GVT shakers, acquisition systems, etc.) and accurate measurements guaranteed capability ii) large experience in structures, with integrated actuation, stress and functional full scale tests iii) long experience and capability of impact and residual strength testing of stiffened composite panels.
- Design Assurance: Partner with certification following requirements of ISO EN 9100 and

privileges of EASA Part 21 J DOA (Design Organization Approval) and EASA Part 21 G POA (Production Organization Approval) or equivalent.

As it concerns the WT models and full scale device demo design and manufacturing, Applicant shall use an advanced software environment able to trace all technical requirements, their relevant solutions, possible mismatches between requirements and solutions is seen as a key factor of innovation applicable to the project organization and management, in order to minimise risks and reduce costs. In all contexts, Applicant shall use extensively virtual mock-ups and virtual testing techniques.

6. Major deliverables and schedule (estimate)

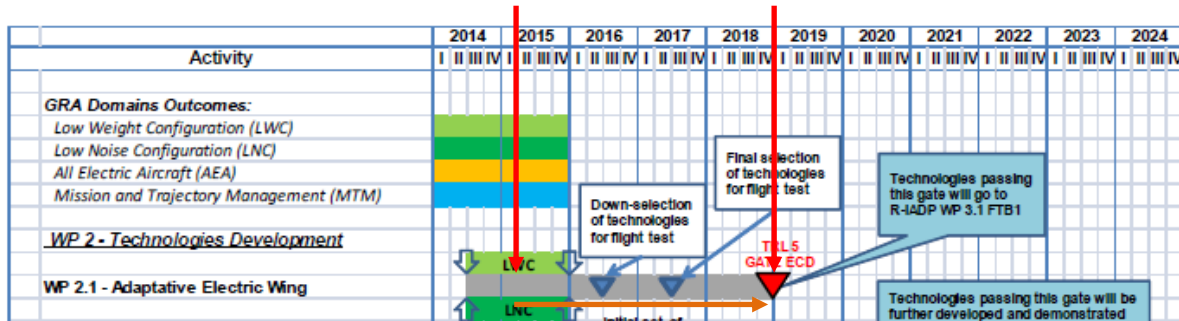
The applicant(s) shall provide deliverables for the proposed activities in accordance with the relevant Preliminary Schedules contained in the JTP chapter 7. Applicant activity start time is corresponding to T0 on April 2015. Core-Partner(s) contributions are requested to start from T0. Therefore relevant CP involvement is requested from T0 up to December 2021 (T0+81). Following table contains a preliminary list of the major deliverables for CP.

Deliverables			
Ref. No.	Title - Description	Type	Due Date
D1	Operational requirements for the integrated design platform wing	Report	T0 + 6
D2	Realization of manufacturing trials to be characterized to verify part quality repeatability and assess the processes	Report	T0 + 7
D3	New adaptive wing devices aerodynamic and aeromechanical design assessment (A/C 2025)	Report/CAE models	T0 + 12
D4	New adaptive wing devices structural design assessment (A/C 2025)	Report/CAE models	T0 + 12
D5	Structural requirements for advanced wing box design	Report	T0 + 12
D6	Operational requirements for SHM-instrumented wing	Report	T0 + 12
D7	Assessment of tolerances and residual stress/defect into assembly design	Report / CAD CAE models	T0 + 12
D8	Technologies suitable for stiffened panels, ribs, spars, miscellaneous parts screened and selected	Report	T0 + 12

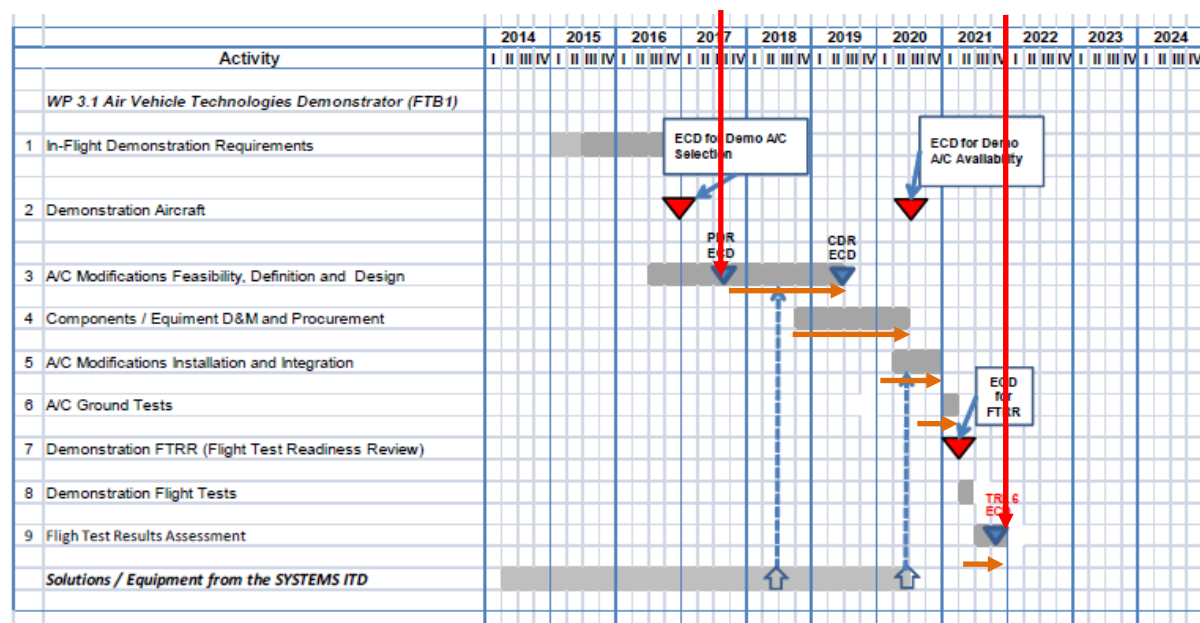
Deliverables			
Ref. No.	Title - Description	Type	Due Date
D9	Test Plan provided according to the building block approach	Report	T0 + 18
D10	New adaptive wing devices aeromechanical assessment validation- Wind Tunnel models, Wind Tunnel test (A/C 2025)	Hardware, Test, Report	T0 + 24
D11	New adaptive wing devices structural assessment validation - Full scale structural demo (A/C 2025)	Hardware & structural tests	T0 + 24
D12	New adaptive wing devices actuation system design assessment (A/C 2025)	Report/CAE models	T0 + 24
D13	SHM/NDI system design architecture	Report	T0 + 24
D14	Design platform theory and code identification	Report	T0 + 24
D15	Wing box LRI Technology Simulation & Development	Hardware & functional tests	T0 + 30
D16	Design of coupons, elements and sub-components including sensor locations to be tested finalized	Report / CAD CAE models	T0 + 30
D17	New adaptive wing devices actuation assessment validation - Full scale control system demo (A/C 2025)	Hardware & functional tests	T0 + 36
D18	Sub-components / Stiffened panels finite element model pre-test predictions, including sensor response, delivered	Report	T0 + 36
D19	Coupons, elements, subcomponents manufactured including NDI, SHM systems installed and ready for test	Hardware	T0 + 40
D20	Integrated methodology Verified up to subcomponents scale finished	Report	T0 + 40
D21	Engineering drawings of new wing movables, wing sub-structures modified parts and relevant mechanisms to be installed on the flight demonstrator FTB#1	CAD models	T0 + 42

Deliverables			
Ref. No.	Title - Description	Type	Due Date
D22	Engineering drawings of new actuation and control system for loads control to be installed on the flight demonstrator FTB#1	CAD Models	T0 + 42
D23	Coupons, Elements, Sub-components Experimental Tests Reports provided	Test report	T0 + 45
D24	SW coding of new load control laws implemented on flight computer FTB#1	CAE Model, report	T0 + 48
D25	Validation of design and structural analysis models and methods up to subcomponent scale finished	Report	T0 + 51
D26	Engineering drawings of new smart demonstrator including wing sub-structures, SHM, NDI and systems to be integrated on the flight demonstrator	CAD models	T0 + 51
D27	Engineering drawings of new SHM and control system for damage control to be installed on the flight demonstrator	CAD Models	T0 + 51
D28	SHM coding of new damage detection approach implemented on flight computer	CAE Model, report	T0 + 51
D29	New wing movables and wing modified sub-structures of flight demonstrator FTB#1	Hardware	T0 + 54
D30	Wing movables new actuation & control system devices (sensors, actuators, etc.) to be installed on the flight demonstrator FTB#1	Hardware	T0 + 54
D31	New wing movables and wing modified sub-structures integrated with actuators and sensors to be installed on the flight demonstrator FTB#1	Hardware, Test, Reports	T0 + 54
D32	Structural (stress and structural dynamics) and functional test of new wing LC&A movables integrated devices FTB#1	Test, Report	T0 + 57
D33	Risk and Value for life cycle analysis	CAE approach	T0 + 81
D34	Structural and functional test of new wing box integrated with SHM devices for damage localization and damage identification	Test report	T0 + 81
D35	Contribution to Project final assessment	Report	T0 + 81

WP 2.1 Core-Partner(s) Involvement



WP 3.1 Core-Partner(s) Involvement



Following table contains a preliminary list major milestones for CP.

<i>Milestones</i>			
<i>Ref. No.</i>	<i>Description</i>	<i>Interface</i>	<i>Due Date</i>
SHORT TERM MILESTONES			
M1	WP 2.1 Adaptive Wing Concepts Technology Maturation- Contribution to First Down Selection	Output to first DS (WAL)	T0+12
M2	WP 2.1 Adaptive Wing Concepts Technology Maturation- Contribution to Final Selection for Flight Tests	Output to final techn. selection (WAL)	T0+24
MEDIUM TERM MILESTONES			
M3	Delivery of WP 2.1 Adaptive Wing Concepts technology experimental validation (WTT and functional)	Output to TRL 5 gate (WAL)	T0+36
M4	Delivery of Sub-components / Stiffened panels finite element model pre-test predictions, including sensor response, delivered		T0 + 36
M5	Delivery of WP 3.1 Adaptive Wing Devices Flight Controls and actuation design for FTB#1	Input: Actuators and FCS from WP 3.4	T0+48
M6	Adaptive Wing Devices Preliminary Design Review		T0+49
LONG TERM MILESTONES			
M7	Delivery of WP 3.1 New wing movables and wing modified sub-structures integrated with actuators and sensors to be installed on the flight demonstrator FTB#1	Output: FTB#1 wing integration (WAL)	T0+54
M8	Delivery of structural (stress and structural dynamics) and functional test of new wing LC&A movables integrated devices FTB#1-	Output : FTB#1 wing qualification permit to fly (WAL)	T0 + 57

Topics for Core-Partners Call 1



<i>Milestones</i>			
<i>Ref. No.</i>	<i>Description</i>	<i>Interface</i>	<i>Due Date</i>
M9	Adaptive Wing Devices Critical Design Review	Output : FTB#1 wing qualificati on permit to fly (WAL)	T0 + 58
M10	Structural and functional test of new wing box integrated with SHM devices for damage localization and damage identification	Test report	T0 + 81
M11	Contribution to final Project assessment	Report	T0 + 81

7. Abbreviations:

A/C	Aircraft
CAE	Computer Aided Engineering
CAD	Computer Aided Design
CFD	Computational Fluid Dynamics
CSM	Computational Structural Modelling
CS2	Clean Sky 2
CP	Core-Partner(s)
D&M	Design & Manufacturing
DOA	Design Organization Approval
FCS	Flight Control System
FHA	Failures Hazard Analysis
FTB#1	Flying Test Bed 1
GRA	Green Regional Aircraft
GVT	Ground Vibration Test
JTP	Joint Technical Proposal
H2020	Horizon 2020
HLD	High Lift Devices
LC&A	Load Control & Alleviation
LH	Left Hand
LRI	Liquid Resin Infusion
NDI	Non Destructive Inspection
NLF	Natural Laminar Flow
OaO	Out of Autoclave
POA	Production Organization Approval
QPP	Qualification Programme Plan
RH	Right Hand
R-IADP	Regional Integrated Aircraft Demonstration Platform
S&C	Stability and Control
SHM	Structural Health Monitoring
TED	Trailing Edge Device
TP	Turbo Prop
WAL	Work Area Leader
WP	Work Package
WTT	Wind Tunnel Test

III. Flight Physics and Wing Integration FTB2

Leader and Programme Area [SPD]	REG		
Work Packages (to which it refers in the JTP)	2.1, 3.5		
Indicative Topic Funding Value	7 Meuros		
Leading Company	EADS-CASA		
Duration of the action	7 years	Start Date	01/01/2015
Date of Issue	01/06/2014	Call Wave	1

Strategic Topic Description

Topic Number	Title		
JTI-CS2-2014-CPW01-REG-02-01	Flight Physics and Wing Integration FTB2	Duration	7 years
		Start Date	01/01/2015

Short description

This Call for Core-Partner(s) proposes a set of activities in the framework of the FTB2 Regional IADP led by EADS-CASA. The Core-Partner(s) will be in charge of activities in the fields of aerodynamic design, analysis and wind tunnel testing, wing components design, manufacturing and wing final assembly. The results of these works will be integrated in “on-ground” and “in-flight” aircraft demonstrators. The technological challenges in all these fields should reach enough TRL to ensure the flight demonstration in the FTB2 Regional Aircraft platform (Full TRL 6).

Flight Physics studies will support wing aircraft analysis and design for three new technology concepts: a multi-functional flap able to operate with continuous setting when deployed and a movable trailing edge for flaps retracted; an adaptive winglet with variable shape depending on the flight condition; and roll and loads control capabilities using innovative spoilers based in flow control devices. General assessment processes for aerodynamics and loads of the A/C wing and Wind Tunnel Test to support them are also included.

Three major wing items are required to be manufactured by the Core-Partner(s):

- Inner External Wing Box: The structural box components (skin, spars, ribs, fittings...) will be metallic and as far as possible compatible with current geometry and integrated with spoiler, flap tracks and actuation systems.
- Aileron: It is foreseen metallic to maintain the size and structural box architecture adapted to interface with a duplicated actuation system (innovative & back-up).
- Spoiler: It is secondary structure with single actuation system interfaces and it is open to integrate technological proposals mature enough to qualify for flight.

The complete External Wing assembly will be performed by the Core-Partner(s), integrating structural components and systems in specimens ready for “on – ground” structural and functional

tests, and “in – flight” specimens. The assembly processes should include mature technology innovations (i.e. jig-less processes, hybrid composite – metallic & composite – composite joints, one-shot-drilling and sealing with eco – friendly materials)

1. Background

This Call for Core-Partner(s) deals with the state of the art in technologies developed within last years in several fields of aeronautics. Flight physics and aerodynamic disciplines applied to aircraft wing design; structural design and system integration in wings and innovative manufacturing processes.

The framework of the activities described in this Call is the Regional Aircraft IADP (Innovative Aircraft Demonstrator Platform) of Clean Sky 2, in particular the Regional Aircraft FTB2 led by EADS-CASA. Related work packages are WP 2.1: Adaptive Electric Wing and WP 3.5: High Lift Advanced Turbo Propeller (FTB2).

The technological lines of this Call for Core-Partner(s) are aligned with the global WAL strategy with respect to the Regional Aircraft FTB2 demonstrator. The framework of the activities are closely linked to Airframe ITD and Regional Aircraft IADP and with lines to be performed by the WAL and other Call Partners along the programme. The WAL will act as project leader and tasks integrator, defining design concepts and feasibility criteria to be finally mounted in the demonstrator. The Intellectual Property rules of the Call will be those Horizon 2020 policy.

▪ **Strategic Role and Mission**

The Core-Partner(s) will play a strategic role for the achievement of the RA-IADP objectives as specified in the JTP. The involvement of the Core-Partner(s) in the RA-IADP must fulfill the following top level objectives which define their overall mission in the RA-IADP

- To implement the resources, capabilities and technical means to secure the fulfilment of the plans according to JTP objectives, deliverables and milestones as defined in this document.
- To provide the specified deliverables and to perform the risk assessment for any technical, economical or scheduling issues
- To accommodate technologies, processes, methods and tools in conjunction with those selected and developed by EADS-CASA and to select the best approaches jointly.
- To integrate into a single team with EADS-CASA within the RA-IADP, facilitating organizational adaptation for the mutual coordination and unified actuation in decisions making, coordination of activities and review of the progress achievements.

The budget of the Call refers exclusively to Core-Partner(s) activities. Subcontracting will follow the Horizon 2020 and Clean Sky 2 general policy.

2. Scope of work

In the framework of Clean Sky 2 programme EADS-CASA participates in the Regional Aircraft IADP (Innovative Aircraft Demonstrator Platform) where several technologic streams will be investigated up to high level of maturity. The objective of most of these technologies is to be tested “in-flight” in the Regional Aircraft FTB2 (Flight Test Bed 2) demonstrator.

The Regional Aircraft FTB2 is a prototype aircraft based on the EADS – CASA C295 model. This aircraft is Civil FAR 25 certified by FAA and EASA Airworthiness Regulations with large in-service experience as regional aircraft which is a perfect platform to test in flight Clean Sky 2 mature technologies.

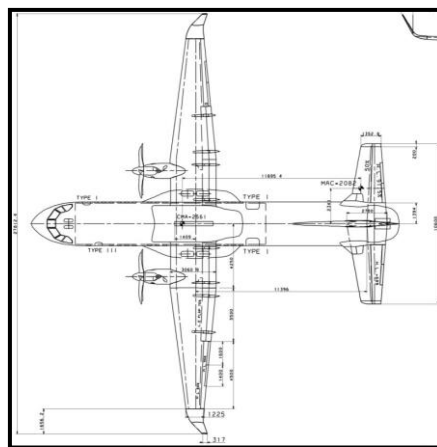


Figure 1: Regional Aircraft FTB2: EADS-CASA C295 aircraft general planform

The main components of the wing are shown in Figure 2. Some of them will be entirely designed within the context of Clean Sky 2, some will be partially modified due to structural or systems interfaces and some remain from the basis aircraft.

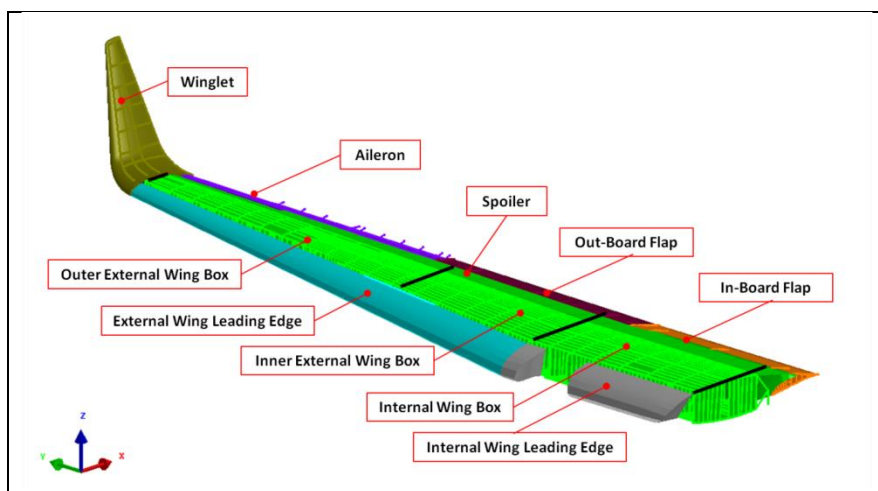
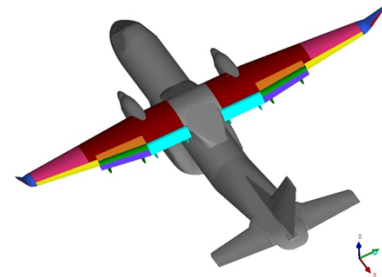
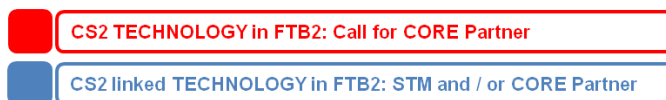
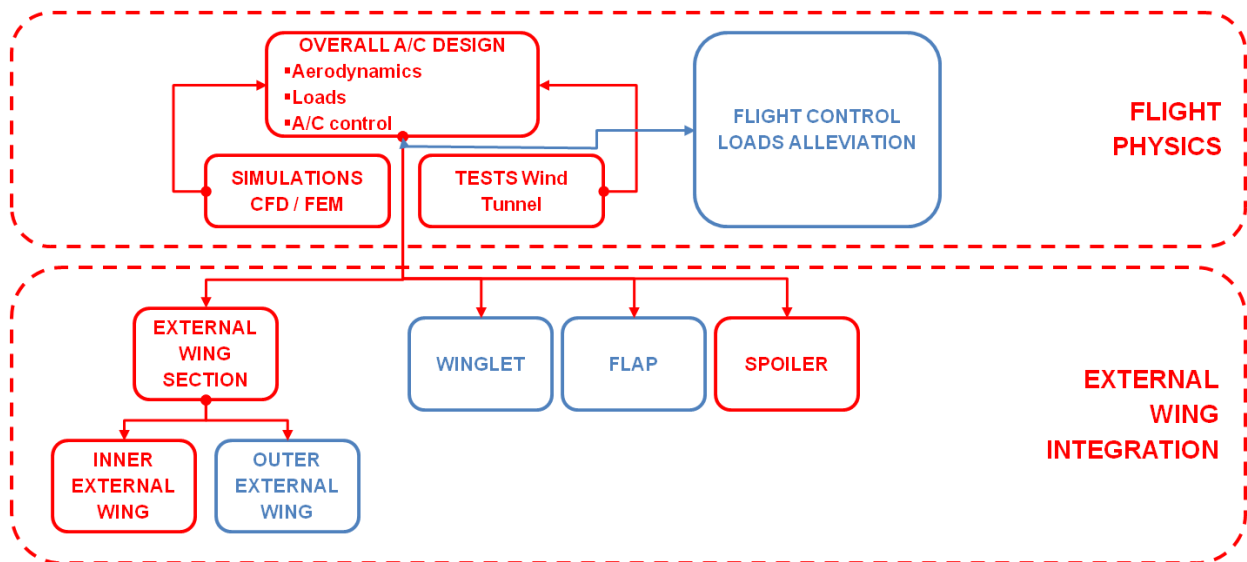


Figure 2: Wing structural components of the Regional Aircraft FTB2—front view-.

The conceptual design of every component will be driven by the WAL (Work Area Leader: EADS-CASA) while detailed design; manufacturing and assembly will be done by the CP (Core-Partner(s)). A high level of concurrent engineering is required. The WALs will require Airworthiness Authorities a Research Permit to Fly (PTF) -NOT Certification- for the Regional Aircraft FTB2 to Airworthiness Authorities. The CP will support this process, being mandatory for that the following activities:

- Providing material data, processes and tools accepted
- Harmonization of calculation processes/tools
- Materials used for primary structural elements must have the qualification level

The Call for Core-Partner(s) covers technology lines all along the Clean Sky 2 Programme and directly linked to the **Regional Aircraft FTB2 demonstrator**. The activities proposed are linked to the WAL (EADS – CASA) activities and other Partners within **Airframe ITD** and **Regional Aircraft IADP** in a global demonstration strategy. The principal activities within this Call are related to **Overall A/C Design (OAD)** in the starting phases of the program, **technology lines for aircraft components manufacturing** of under OAD design principles and finally **integration** of this components into the FTB2 demonstrator. The **interdependencies and interfaces** between the CP/WAL activities of this Call –in red- and the rest of the program (WAL or other Partners) –in blue- are shown in the following sketch. . Due to the fact that the activities within this call are oriented to a flight demonstration, the WAL will play an integrator role in all the activities.



The Call for Core-Partner(s) is organized in three main parts summarized in Tables 1 to 3. The description of activities and responsibilities share between WAL and CP is detailed in following chapters. Budget involved in this Call cover specifically CP activities.

COMPONENT	TECHNOLOGY CHALLENGES	TECHNOLOGY DEMONSTRATORS
OAD	A/C Integration of different complementary technology concepts for aerodynamic efficiency and loads control.	WTT demonstration of the integration of all the new wing concepts FTB2: overall A/C performances in any a/c configuration for all flight phases.
FLAP	Multi-functional Flap able to operate in continuous setting and with a subcomponent for operation with flap retracted.	WTT demonstration of flap concept FTB2: New outboard flaps concept and new kinematics
WINGLET	New secondary control surface concept in winglet with morphing characteristics for larger drag and loads reduction.	WTT demonstration of winglet concept FTB2: New movable in winglet.
SPOILER	Active Flow Control devices used for roll and loads control as alternate to conventional spoiler device	WTT with flow control for roll and loads control. FTB2: loads control demonstration.
WIND TUNNEL	New aerodynamic movable device concepts and flow control for loads control concept suited to WTT	WT Model and WT Test for development and validation of all the concepts

Table 1: Flight Physics Work Packages and main technology challenges for the Core-Partner(s)

COMPONENT	TECHNOLOGY CHALLENGES	TECHNOLOGY DEMONSTRATORS
INNER EXTERNAL WING SECTION	Modification of current design using mature technologies to incorporate: - Outboard flap - Spoiler - Flap and spoiler actuator systems - Innovative attachments - Mature technologies	• 1 specimen for “on –ground” static and functional tests. (RH wing section). • 2 specimens (LH and RH wing sections) ready for flight
AILERON	Active loads alleviation (MLA and GLA) Integration of EMAs Modification of current design to	• 1 specimen for “on –ground” static and functional tests. (RH aileron).

COMPONENT	TECHNOLOGY CHALLENGES	TECHNOLOGY DEMONSTRATORS
	incorporate new actuation system - Innovative attachments - Mature technologies	• 2 specimens (LH and RH ailerons) ready for flight.
SPOILER	Active loads alleviation (MLA and GLA) Integration of EMAs Aircraft performance in landing and take-off configurations New design to incorporate new actuation system - Composite or metallic - Innovative technologies	• 1 specimen for “on –ground” static and functional tests. . (RH side spoiler. • 2 specimens (LH and RH spoilers) ready for flight.

Table 2: External Wing structural components manufactured by the Core-Partner(s)

COMPONENT	TECHNOLOGY CHALLENGES	TECHNOLOGY DEMONSTRATORS
EXTERNAL WING INTERGRATION	Jig-less assembly concepts for the external wing components integration Assembly of highly integrated composite components OSD and OSA processes Innovative processes for aileron structural fittings, EMAs attachments and systems supports: - Light metallic alloys with enhanced characteristics (strength, fatigue) - Super-plastic forming, Additive Layer Manufacturing, ... Hybrid metallic-composite joint technologies. Enhanced shimming processes. Inspection of shape control Production time reduction. Energetic and environmental costs reduction.	• 1 specimen for “on –ground” static and functional tests. (RH wing section). • 2 specimens (LH and RH wing sections) ready for flight

Table 3: External Wing Integration activities and main technology challenges for the Core-Partner(s)

The Technology Demonstrators, regarding structural components and wing integration activities, are:

- One wing component (R/H) to be qualified on ground through a major testing by the WAL.
- Two wing components (RH/LH) ready-for-flight to be integrated in the FTB2 by the WAL.

The Core-Partner(s) will provide the achievements with respect to Horizon 2020 and ECO-Design objectives along the program. The results of the works need to be evaluated in terms of environmental and productivity objectives aligned with Clean Sky 2 strategy (CO₂ and NO_x emission reductions, fuel consumption efficiency and noise footprint impact) versus the current existing ones technologies.. Specific reports focus on this aim will be performed by the WAL and CP.

a. FLIGHT PHYSICS CONTENTS

The flight physics activities involve new advanced concepts for a multifunctional flap, an adaptive winglet and fluidic devices for roll and loads control. These activities are mainly the aerodynamics design and optimization of the devices, their integration within the OAD and the analysis of their impact on the wing loads as well as the characterization regarding the HQ and controllability. Computational models and wind tunnel models have also to be created and tested as support to these activities.

▪ Work Packages

The activities to develop by the CP in the Flight Physics chapter are grouped in five work packages as in Table 1 devoted to the flap, winglet, spoiler and general packages for WTT and OAD

▪ General Description

The overall activities in OAD devoted to the FTB2 within the RA-IADP are focused in the wing, for which different new technology concepts will be developed, integrated and tested in flight. These concepts have to be designed, modelled, simulated, analyzed, optimized, and tested in wind tunnel before flying in full scale at the A/C.

Figure 3 shows the layout of the wing aerodynamic surfaces of the FTB2 differentiated by colour as well as other wing parts that will be modified for the FTB2. The titles in the boxes indicate the WP's defined in this document for the CP, two of them (OAD and WTT) involve the whole A/C and all the aerodynamic concepts.

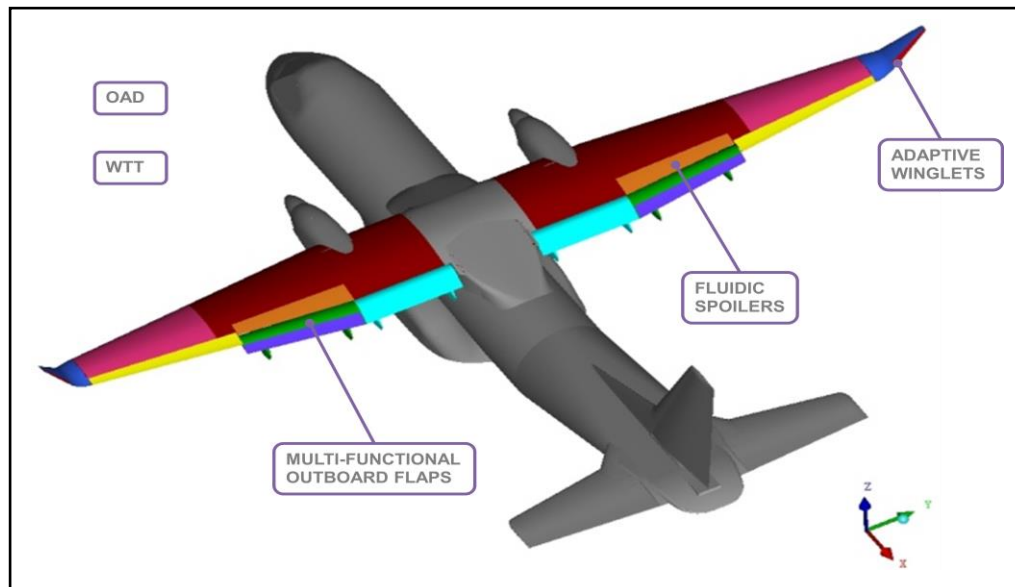


Figure 3: Wing Components, Concepts and Control surfaces.

▪ CAPACITY AND TECHNOLOGY DOMAIN (CTD)

The involvement of the Core-Partner(s) in the Flight Physics chapter will be in the Aerodynamics and the Loads domains in the following processes:

- Aerodynamics simulation and related processes: CAD models generation and modification. CFD models and computations, FEM models and computations, Fluid-Structure Coupling.
- Aerodynamics design.
- Data Handling. Aerodynamic data set generation. Drag prediction. WT Data correction.
- Wind Tunnel. WT Models design. Test campaigns.
- Loads Models. Industrial loads modelization. Loads prediction.
- Loads Control
- Flow Control

It's requested the adequate staff size with knowledge and expertise in these technology domains. Additionally, the requested capacity of the CP regarding the Flight Physics chapter is in terms of:

- HPC and H/W resources
- WTT facilities

a.1. OAD

The Overall A/C Design activities for the FTB2 lead by EADS-CASA include the preliminary and detailed design of new concepts for aerodynamics performance and loads control, its integration in the A/C, their assessment in WT and FT and the clearance of the loads and HQ of the A/C before the flight. The WAL, in the roll of aircraft integrator, will coordinate the activities with preponderant responsibilities in OAD with respect to the CP.

The activities proposed in this WP for the Core-Partner(s) will be developed in close cooperation with EADS-CASA and are mainly devoted to the aerodynamics and loads assessment and other supporting activities for doing it.

In the aerodynamics side the activities will focus in the generation of reference CFD models of the complete A/C, in its integration of the specific models for each technology device and the generation of aerodynamic data sets.

For both, the aerodynamics performances and the loads, the elasticity effects will also be taken into account by the CP by means of adequate FEM model. The responsibility of the concepts assessment is shared between EADS-CASA and the Core-Partner(s).

▪ Activities

1. CFD Modelling of the complete aircraft both power-off and power-on including all flap configurations (4) and all flight controls. CFD models for Power On simulation should include at least two types of propeller models: a lower fidelity one (e.g. actuator disk model) and a high fidelity one (e.g. rotating propellers using sliding grids).
2. Integration of all the concepts (spoiler, flap and winglet) into the reference CFD model and overall A/C performances prediction through simulation in take-off, landing, climb and cruise.
3. Prediction of the wing loads reduction due to the different wing devices integrated in the new configuration for the FTB2 (spoiler, flap and winglet) and generation of a predictive loads model allowing to clear the configurations for flight tests.
1. Generation of reference FEM model of the A/C to be coupled with CFD.
2. Elasticity effects at 1g and max loads factor in the A/C aerodynamic performances and wing loads evaluated by CFD/CSM coupling
3. Assessment of concepts integrated in the A/C against WTT and FT

▪ Specific Requirements

- CFD models must be compatible with the standard at EADS-CASA (reference is ANSYS CFX) based in unstructured grid with non-conformal curved surface interfaces.
- FEM models must be ready for 2-way coupling to CFD model. FEM model must be assessed against existing NASTRAN model for representative loads cases for the wing in terms of deformations and elastic modes.

a.2. FLAP

The FTB2 will test a new technology concept for the flaps in the outer flap as indicated in Figure 3. The multifunctional flap concept pursues to optimize the performances of the A/C in all flight phases. It will operate at any setting deflection within the whole range for those A/C operations with flaps deployed instead of operating at certain limited settings. In addition, the flap will include a movable trailing edge that can be operated when flap is retracted to improve wing efficiency at all cruise conditions. Flap geometry and kinematics will be optimized in collaboration with EADS-CASA. The CP will lead the activities of the flap aero – design and receive feedback from the WAL to ensure the

integration in the FTB2 demonstrator. The responsibility of the concepts assessment is shared between EADS-CASA and the CP.

- **Activities**

1. CFD Modelling of the new multi-functional flap. Assessment of the predictive capabilities against WTT. Improvement of the model based in post-test analysis.
2. Flap Design: CFD computations (2D and 3D) exploring the design space of the flap
Aero dataset generation: Computations for the complete A/C in the complete range of flap deflection. Computations for the complete A/C with flaps up in cruise conditions for different deflections of the movable flap TE

- **Specific Requirements**

- CFD models with new flap must be able to perform the variation of the flap setting and shape geometry during the executing time through mesh deformation.

a.3. WINGLET

A new adaptive winglet for C295 will be designed including a control surface in the trailing edge. The new winglet capabilities are threefold: Firstly, the new winglet concept pursues to improve the capability of conventional winglets optimizing the drag reduction at any flight phase by using movables as secondary control surfaces. The wing loads and the controllability of the A/C are other aspects to take into account and to improve respect to a conventional one. Aero-elastic tailoring concepts applied to winglet for passive loads alleviation is the third aspect to analyse and to improve respect to conventional winglets. Within this framework, the winglet geometry, the control surfaces on winglet and their kinematics, and the aero-elastic effects shall be analysed and optimized by the CP in collaboration with EADS-CASA. The Core-Partner(s) will lead the activities of the winglet aero – design and receive feedback from the WAL to ensure the integration in the FTB2 demonstrator. The responsibility of the concepts assessment is shared between EADS-CASA and the Core-Partner(s).

- **Activities**

1. CFD Modelling of the new adaptive winglet: Generation of watertight CAD model for CFD. Mesh Generation and integration into the complete A/C. CFD Model setup.
2. Winglet design: CFD computations 3D exploring the design space of the adaptive winglet
3. Aero dataset generation: Computations for the complete A/C in different representative flight phases with different winglet deflections
4. Data validation against WTT
5. Flexibility effects evaluation and assessment through CFD/CSM coupling

a.4. SPOILER

Within the framework of the loads control and loads alleviation concept developed by EADS-CASA in Clean Sky 2, and as an alternative to a conventional spoiler device, it is pursued to evaluate the capabilities of fluidic devices to perform loads alleviation and roll control in similar way to that desired of a conventional spoiler.

The objective of the Core-Partner(s) is to provide an active flow control concept suitable for the A/C configuration to test in FTB2, and to evaluate and assess its capabilities through CFD and WTT and to design the concept for the FTB2 and to predict their performances at real scale in flight. The Core-Partner(s) will lead the activities of the spoiler aero – design and receive feedback from the WAL to ensure the integration in the FTB2 demonstrator. The Core-Partner(s) has complete responsibility in all the technologies involving this spoiler concept.

▪ Activities

1. Design and development of an active flow control concept to perform loads control and adaptation to the C295 configuration
2. CFD model for the flow control devices and integration within the complete C295 CFD model.
3. Generation of aero data sets
4. CFD spoiler effects validation against WTT and comparison with conventional spoiler.

a.5. WIND TUNNEL

As for the OAD, this work package involves the whole A/C and is intended to provide the aerodynamic experimental data in a scaled WT model that will be used to assess the predictions by simulation of the different technology concepts previous to integrate at the A/C level for the FTB2.

The aim of the Core-Partner(s) activity is to design a low speed WT model of the complete A/C to be tested both at the Core-Partner(s) own facility and also at a large Reynolds number facility (pressurized wind tunnel). The tests at the Core-Partner(s) own facility would be devoted to investigate the optimal settings of the concept devices, to the validation of the concepts and to the determination of the preliminary performances of different concepts in this proposal whereas the high Reynolds tests would be devoted to the high quality data gathering needed for the PTF of the FTB2 prototype. The roll of the Core-Partner(s) will be preponderant in the design of the WT model and WT data generation that will support the design proposed by OAD and every single components affected by individual technological lines (flap, winglet and spoiler).

▪ Activities

1. Design of a Powered Wind Tunnel Model (WTM) of the complete C295 A/C including the propellers and all primary and secondary device controls.
2. Design and manufacturing of the strut/s for own WTT (struts to be compatible with large Re WT).
3. Design and integration in the WTM of new devices: adaptive winglet and multifunctional flap

4. Design manufacturing and integration in the WTM of fluidic devices for loads and roll control
5. WTT campaigns to investigate the new concepts and to find and to derive the optimal devices settings. Data provision for assessment of the concepts
6. WTT campaigns at low speed with new devices and Power On and Power Off for general characterisation of the whole A/C.
7. Data analysis, correction, and transposition to flight scale.

▪ WT Requirements

- Wind tunnel model (WTM) of the complete C295 A/C (both sides) must be fully representative of the existing configuration (fuselage, wing, winglet, tails, nacelles, sponsor's, landing gear, flap track fairings, flaps, ailerons, elevator, rudder) and of the innovative configuration (fluidic spoilers, new flap and winglet concepts).
- Wind tunnel model must be suitable for low speed (Core-Partner(s) WT own facilities) and for pressurized (high Re number).
- Propeller drive and control system according to the model scale and the max demand from propellers at the different test conditions.
- Variable pitch propellers provided by EADS-CASA.
- 6 DOF rotary shaft balances and associated data acquisition system.
- Pressure taps located at different wing sections, including taps on the flaps and in winglet sections.
- Reference minimum span of the C295 complete WT Model is 3m. Core-Partner(s) own WT facilities must be able to accommodate that minimum span.

b. EXTERNAL WING COMPONENTS

b.1. INNER EXTERNAL WING SECTION

▪ Component general description

The Inner section of the External Wing (reference dimensions: span 3860 mm and root chord 3000 mm) will be redesigned and manufactured to demonstrate innovative technologies. This component should be based on the EADS – CASA C295 aircraft at foreseen mainly affected by the integration of spoiler, flap tracks and their respective actuation systems. The structural box components (skin, spars, ribs, fittings...) will be metallic and as far as possible compatible with current geometry, and it should include the technological challenges proposed within the Clean Sky 2 programme. Figure 4 shows the present general arrangement of the External Wing box. The contour of the Inner External section, which includes the torsion box and the trailing edge area, is marked in blue colour.

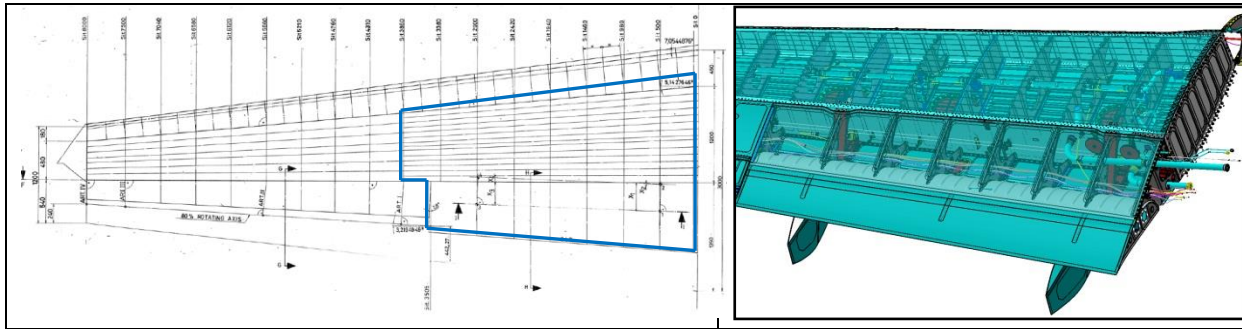


Figure 4: External Wing of the Regional Aircraft FTB2

Proposed innovative technologies with high TRL will be incorporated in the design phase in accordance with the WAL like:

- Specific and optimum design of attachments for a new continuous deployment Outboard flap
- Optimum design to include a new Spoiler with Electro-Mechanics Actuators (EMA)
- Light metallic alloys with enhanced characteristics (strength, fatigue)
- Super-plastic forming (SPF) and/or Additive Layer Manufacturing (ALM): to those parts where these technologies may add some value for “in – flight” demonstrators (i.e. supports, redundant or low responsibility fittings)
- Inspection of shape control (spring-back)
- Enhanced shimming processes
- Design of hybrid complex joints (composite / metallic and composite / composite): between Inner External Wing Section and the Outer External Wing Section
- New sealing techniques with eco – friendly materials preserving tolerances and tightness in fuel tanks

Innovations in design will be focus on:

- Innovative joint of the Inner External Wing box (metallic) with the Outer External Wing box (composite) by means of a riveted shear joint with metallic splices.
- New design of the trailing edge area to host new Out-board Flap and the new Spoiler:
 - Redesign of outboard flap fittings and tracks.
 - Trailing edge panels and shape ribs to incorporate the spoiler.
 - Innovative fittings for the new actuation system of EMAs in flap and spoiler.

The conceptual design of the component will be provided by the Work Area Leader, meanwhile detail design, sizing, parts manufacturing, quality assurance and low level tests are responsibilities of the Core-Partner(s). Design requirements will be fixed by the Work Area Leader (external aero shape, installations, weight target, stiffness, deployment kinematics, system integration ...)

▪ Activities

1. Preliminary design modification of inner external wing box section. (WAL)
2. Material selection of modifications.(CP)
3. Manufacturing process of modifications. (CP)
4. Detail Design and Analysis of component.
 - a. Solid models and detail drawings, including systems provisions defined in the document of High level Requirements. (CP)
 - b. Dimensioning and structural analysis of the structure considering loads provided by the WAL. (CP)
5. Tooling design and manufacture. (CP)
6. Manufacturing plan and full process. (CP)
7. Production of the full scale specimen for structural and functional tests (CP)
8. Non Destructive Inspection (NDI) and quality assurance. (CP)
9. Support to wing structural and functional test: preparation and analysis (CP in cooperation with WAL)
10. Production of specimens ready for flight to be assembled in the aircraft. (CP)
11. Non Destructive Inspection (NDI) and quality assurance. (CP)
12. Component documentation and support to PTF process. (CP)
13. Evaluation of Horizon 2020 environmental and productivity objectives at component level. (CP)

(*) Activity responsible in parenthesis (WAL: Work Area Leader, CP: Core-Partner(s)).

b.2. AILERON

▪ Component general description

The aileron of Regional Aircraft FTB2 has reference dimensions 250 x 4500 mm with three attachments to the wing rear spar and two actuators. Structural modifications of this component are motivated by the new design of EMAs driven by an Active Loads Alleviation System (MLA and GLA) in the aircraft. Activities to be performed in the aileron are modifications for adaptation of the control surface to new actuation system requirements.

Modifications will be focus on:

- Aileron trailing edge re-design to block tabs (trim and geared tabs) or an alternative design
- Redesign of actuators attachments to withstand innovative actuation system requirements
- Counter-weights elimination keeping control surface within weight and centre of gravity limits

Therefore the current aileron design is the baseline where structural modifications will take place. It is foreseen to maintain the overall size and structural box architecture adapted to interface with a

duplicated actuation system (innovative & back-up), therefore, it is foreseen to be metallic. The objective of works in this component is the adaption of the structural architecture to host highly integrated systems for aircraft control and load alleviation system (MLA and GLA).

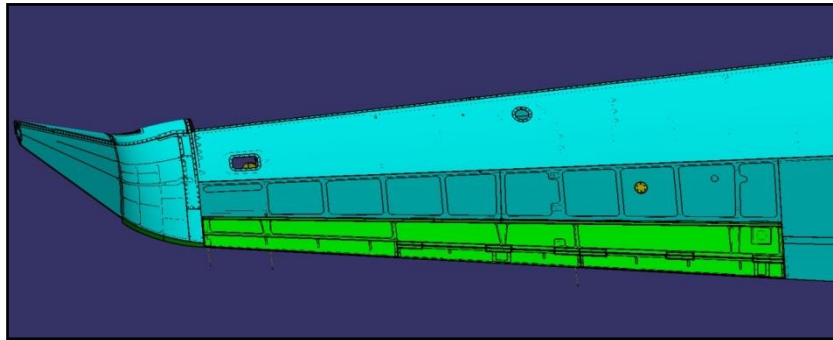


Figure 5: Aileron component

Design requirements will be fixed by the WAL (external aero shape, installations, weight, stiffness, loads, definition of actuation systems and interfaces, lightning protection, interchangeability ...)

▪ Activities

1. Preliminary design modification of current aileron to include a new actuation system for loads alleviation (MLA and GLA) (WAL)
2. Material selection of modifications (CP)
3. Manufacturing process of modifications.(CP)
4. Detail Design and Analysis of component in accordance with manufacturing process.(CP)
 - a. Solid models and detail drawings, including systems provisions defined in the document of High level Requirements.(CP)
 - b. Dimensioning and structural analysis of the structure considering loads provided by the WAL.(CP)
5. Tooling design and manufacture.(CP)
6. Manufacturing plan and full process. (CP)
7. Production of the full scale specimen for structural and functional tests. (CP)
8. Non Destructive Inspection (NDI) and quality assurance.(CP)
9. Support to wing structural and functional test: preparation and analysis (CP in cooperation with WAL)
10. Production of specimens ready for flight to be assembled in the aircraft.(CP)
11. Non Destructive Inspection (NDI) and quality assurance. (CP)
12. Component documentation and support to PTF process. (CP)
13. Evaluation of Horizon 2020 environmental and productivity objectives at component level. (CP)

(*) Activity responsible in parenthesis (WAL: Work Area Leader, CP: Core-Partner(s)).

b.3. SPOILER

▪ Component general description

The FTB2 Regional Aircraft will include a new spoiler as a key component for technology demonstrations to improve performances in take-off and landing configurations. The spoiler will be driven by two actuators attached to the wing box. The functionality of this new spoiler is to be part of the active loads alleviation system (MLA and GLA) with innovative actuators (EMAs).

The baseline design will be provided by the WAL in the early stages of the project, on top of which several technology concepts will be studied and manufactured. The spoiler can be considered as secondary structure with single actuation system interfaces and it is open to integrate technological proposals as far they can be qualified for flight (i.e. fluidic-spoiler).

Design requirements will be fixed by the Work Area Leader (external aero shape, installations, weight, stiffness, loads, definition of actuation systems and interfaces, lightning protection, interchangeability, kinematics ...)

▪ Technology challenges

The first activities of the Work Area Leader are to perform a trade-off between different spoiler concepts where innovations will be analysed (i.e. innovative actuation systems in conventional aero-shape, fluidic-spoiler concepts –feasibility-, air-feeding implementation, etc.). Among these alternatives one spoiler design will be selected for manufacturing and the Core-Partner(s) will start the detail design, structural sizing, material selection and manufacturing processes.

Spoiler deployment kinematics is responsibility of the Core-Partner(s), while the actuation system will be fixed by the Work Area Leader and other Partners. Materials and quality of the processes must be assured to support the final assembly in the demonstrator for a flight test campaign in the Regional Aircraft FTB2.

▪ Activities

1. Structural trade-off of different spoiler concepts in accordance with conceptual design provided by the WAL: deployment kinematics, deployment actuation and system interfaces. (CP) in accordance with WAL).
2. Preliminary Design of component considering general requirements established by the WAL: aero-shape, functionality, systems provisions in structural design, etc. (CP)
3. Material selection. (CP)
4. Manufacturing process development. (CP)
5. Detail Design and Analysis of component in accordance with manufacturing process maturity.
 - a. Solid models and detail drawings, including systems provisions defined in the document of High level Requirements. (CP)
 - b. Dimensioning and structural analysis of the structure considering loads provided by the WAL. (CP)

6. Tooling design and manufacture. (CP)
7. Manufacturing plan and full process. (CP)
8. Production of the full scale specimen for structural and functional tests. (CP)
9. Non Destructive Inspection (NDI) and quality assurance. (CP)
10. Simplified structural and functional tests to ensure spoiler deployment: contactless surface metrology (CP)
11. Support to wing structural and functional test: preparation and analysis (CP in cooperation with WAL)
12. Production of specimens ready for flight to be assembled in the aircraft. (CP)
13. Non Destructive Inspection (NDI) and quality assurance. (CP)
14. Component documentation and support to PTF process. (CP)
15. Evaluation of Horizon 2020 environmental and productivity objectives at component level. (CP)

(*) Activity responsible in parenthesis (WAL: Work Area Leader, CP: Core-Partner(s)).

c. INTEGRATION OF EXTERNAL WING

▪ External wing assembly general description

All new components of the Regional Aircraft FTB2 External Wing will be integrated incorporating technology innovations aligned with Clean Sky 2 principal objectives and taking the baseline of the C295 aircraft. The External Wing to be assembled has reference dimensions of 8000 mm span, 3000mm root chord and 1200 mm tip chord. The assembly will include structural components and systems.

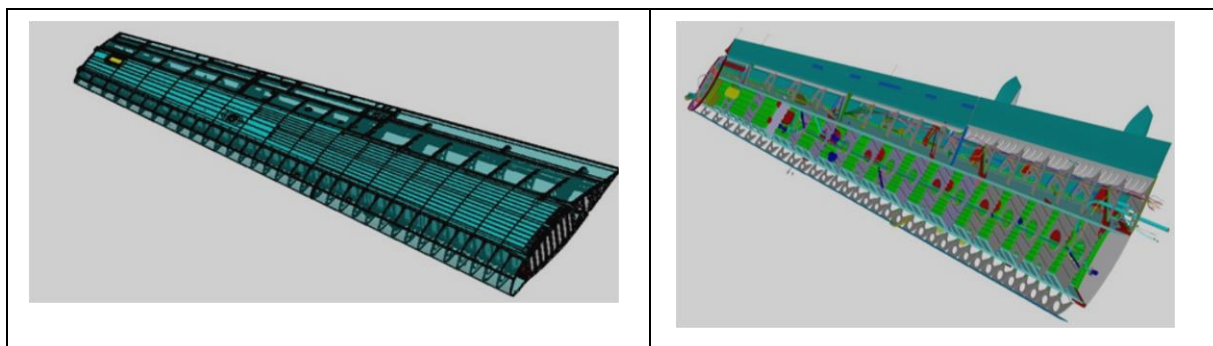


Figure 6: Structural components –left- and systems –right- of the Regional Aircraft FTB2 Wing

The outer wing is divided in the following main structural sections:

- External Wing box: Inner - External Wing box and Outer - External Wing box
- Trailing Edge Aileron section
- Trailing Edge Flap section
- Leading Edge section
- Aileron

- Out Board Flap

The process map of the Regional Aircraft FTB2 External Wing is sketched in Figure 7 where main structural components, subassemblies and assemblies are summarised.

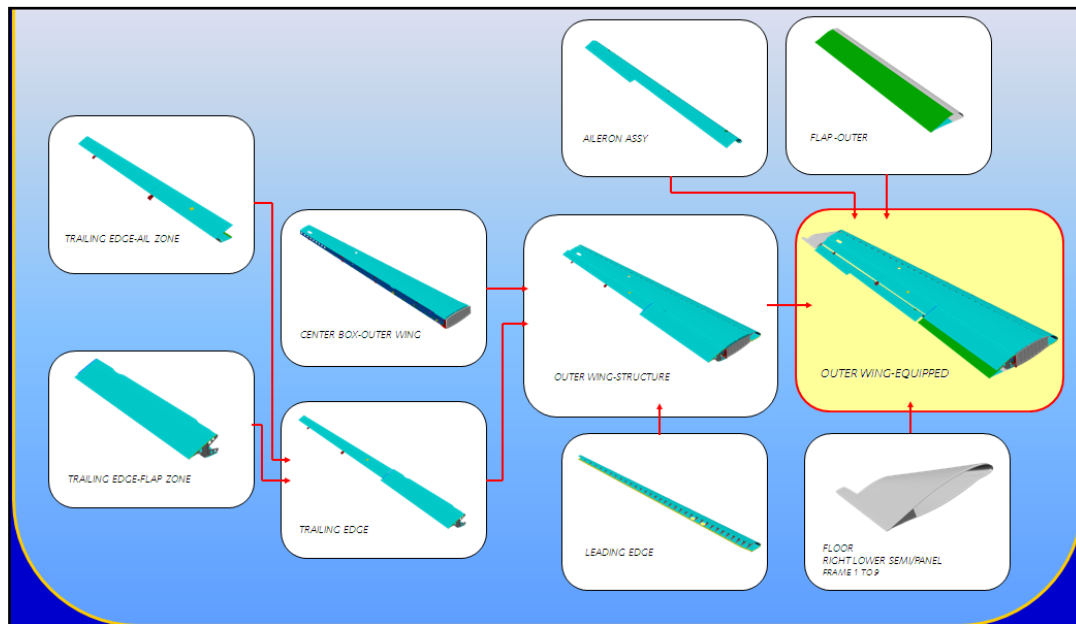


Figure 7: Aircraft FTB2 External Wing Assembly process

Technology challenges

The External Wing of the Regional Aircraft FTB2 has been selected as demonstrator of technologies regarding: aircraft performance improvements (i.e. morphing winglets and continuous flap), Active loads alleviation systems (MLA and GLA), highly integrated structure and systems for more efficient actuation: (EMAs) and Innovative materials and manufacturing processes (Composites, ALM, OoA)

The Integration of the External Wing should deal also with specific technologies which reduce the global lead time and reduce energetic and environmental assembly costs like:

- Innovative jig-less techniques to reduce tooling costs: aircraft structures require jigs for assembling; however the major trend in aircraft assembly is to employ technology in the reduction, and potential elimination, of heavy accurate jigs.
- Advanced assembly processes in hybrid complex joints (composite / metallic and composite / composite): challenges resulting from joining highly integrated composite components of the outer external wing meeting the required aerodynamic external geometry and surface tolerances. Also, innovative materials (i.e. light metallic alloys with enhanced characteristics) and manufacturing processes (i.e. ALM) are expected for the aileron and actuator fittings and

installations brackets.

- One-Shot-Drilling and On-Shot-Assembly which simplify riveting and joining operations: Riveting processes are also fundamental during aeronautical assembly. Technologies to increase accuracy with faster procedures are also the cutting edge in industry.
- New sealing techniques with eco – friendly materials preserving tolerances and tightness. Sealing operations are also a mayor issue during assembly. Research of new sealing materials that can be applied during the assembly processes accomplishing tightness and seat are very welcomed.

■ Activities

- Subassemblies: Flap Ribs, Trailing Edge - Flap zone Integration, Subassembly of small parts (ribs, skin, spares, fittings), Aileron Ribs and Trailing Edge - Aileron zone Integration
- Structural Integration (Main Feature): Integration of Central Box (Spares and Ribs), Integration of Central Box (Skins) and Integration of Central Box with Trailing Edge
- Sealing, Fuel System and Lower Skin (Additional Feature): Sealing Fuel Tank, Mounting Fuel System, Trailing Edge Covers Integration and Integration of inferior central skin
- Equipment of the Wing and Painting: Wing out of fixture (Jig), Mounting anchor nuts, Fuel covers, Preparing connections to wing box, Cleaning and Sealing, Mounting electrical harnesses of Fuel System, Leakage test, Electrical resistance test, Aileron's fitting assembly, Make water proof the tank (Zero rib), Painting, Wing Equipment (Anti-ice / flying control system), Trailing Edge electrical harnesses, Leading edge electrical harnesses and Wing Tip / Winglet

3. Capabilities and Special skills

- Experience in aeronautics and involvement with airframe industry
- Experience and knowledge of turboprop A/C type
- Knowledge and experience in CFD and related processes
- Experience in coupled processes to CFD (Matlab, CATIA, FEM).
- Knowledge and Experience in High Lift
- Experience in loads control by flow control
- Experience in winglet design
- Experience in design and manufacturing of structures in innovative metallic components (i.e. ALM and SPF)
- Capacity to assembly composite and metallic parts; and hybrid joints: Drilling and riveting of composite parts in composite-composite o metallic-composite joints.
- Capacity to design and manufacture electrical harnesses.
- Design and analysis tools of the aeronautical industry (i.e. ANSYS CFX, CATIA v5 release 21, NASTRAN)
- Competence in management of complex projects of research and manufacturing technologies.

- Experience in integration multidisciplinary teams in concurring engineering within reference aeronautical companies.
- Proved experience in collaborating with reference aeronautical companies with industrial air vehicle developments with “in – flight” components experience.
- Participation in international R&T projects cooperating with industrial partners, institutions, technology centres, universities and OEMs (Original Equipment Manufacturer).
- Capacity of providing large aeronautical components within industrial quality standards.
- Capacity to support documentation and means of compliance to achieve prototype Research “Permit to Fly” with Airworthiness Authorities (i.e. EASA, FAA and any others which may apply).
- Experience in technological research and development in the following fields:
 - Highly integrated structures (i.e. production rate, cost, and weight savings).
 - Assembly of large size structures: composite and metallic.
 - Process automation.
 - Jig-less assembly concepts for large components integration
 - OSD and OSA processes
 - Innovative processes for structural fittings, EMAs attachments and systems supports:
 - Hybrid metallic-composite joint technologies.
 - Enhanced shimming processes.
- Capacity to repair “in-shop” components due to manufacturing deviations.
- Capacity to provide support to structural and functional tests of large aeronautical components:
 - Tests definition and preparation: stress and strain predictions, deformed shape prediction and instrumentation definition
 - Analysis of test results
- Capacity to support to Air vehicle Configuration Control.
- Capacity of performing Life Cycle Analysis (LCA) and Life Cycle Cost Analysis (LCCA) of materials and structures.
- Capacity of evaluating results in accordance to Horizon 2020 environmental and productivity goals following Clean Sky 2 Technology Evaluator rules and procedures.
- Capacity of evaluating design solutions and results along the project with respect Eco-Design rules and requirements.
- Design Organization Approval (DOA).
- Product Organization Approvals (POA).
- Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004)
- Core capabilities in WTT for research in low speed (Mach=0.2 must be attainable)
- HPC resources
- Mechanical manufacturing processes, in both composite and metallic.
- Facilities and tooling for the external wing box integration.
- Processes and tools for drilling and riveting Composite in mechanical joints and Hybrid joints (Composite + Metal).
- Equipment and tooling for metallic parts manufacturing (i.e. classical processes, ALM and SPF).
- Non Destructive Inspection (NDI) and large components inspection:

Topics for Core-Partners Call 1



- Dimensional inspections
 - Materiallography
- Contactless dimensional inspection systems - Simulation and Analysis of Tolerances and PKC/AKC/MKC (Product, Assembly and Manufacturing Key Characteristics).

4. Major Deliverables and schedule (estimate)

Deliverables and schedule according to Top Level Plans at the time of the Call preparation. The initiation of activities (T_0) is a reference date within the interval of Regional Aircraft IADP and Airframe ITD master plan beginnings –i.e. mid 2014 to mid-2015.

Deliverables				
	Ref. No.	Title - Description	Type	Due Date (months)
OAD	<i>D.1.1.1</i>	Aerodynamic an Loads Assessments against WTT - <i>Assessment of CFD results against WTT</i> - <i>Overall A/C aerodynamic assessment</i> - <i>Overall A/C loads assessment</i>	<i>Simulation Models and Results files Report</i>	$T_0 + 30$
	<i>D.1.1.2</i>	Aerodynamic an Loads Assessments against FT - <i>Overall A/C aerodynamic assessment</i> - <i>Overall A/C loads assessment</i>	<i>Models Report</i>	$T_0 + 70$
FLAP	<i>D.1.2.1</i>	Multifunctional Flap Design and optimization - CAD model Parameterized for the Flap and Kinematics - CFD models - <i>CFD results from flap optimization process</i> - <i>Final Geometry of the optimized flap</i>	<i>CATIA model Data Files</i>	$T_0 + 18$
	<i>D.1.2.2</i>	Multifunctional Flap Assessment and aerodynamic data set generation - <i>CFD results validation against WTT</i> - <i>Post-Test computations and correlation to WTT</i> - <i>Data generation for the A/C</i>	<i>Report Data Files</i>	$T_0 + 30$
WINGLET	<i>D.1.3.1</i>	CAD model for CFD of the C295 including the Adaptive winglet - <i>Parameterized CAD geometry</i> - <i>Clean watertight surface model</i> - CFD model	<i>CATIA model Data Files Report</i>	$T_0 + 8$
	<i>D.1.3.2</i>	Adaptive Winglet optimization. - CFD results of the C295 exploring the design space - CFD results of the C295 with the final design of Adaptive Winglet. Prediction for different flying conditions	<i>Data Files Report</i>	$T_0 + 18$

Deliverables				
	Ref. No.	Title - Description	Type	Due Date (months)
	D.1.3.3	Assessment CFD results of the C295 with Adaptive Winglet against WTT. Post-test computations and correlation	Models Report	$T_0 + 30$
SPOILER	D.1.4.1	<i>Design of Flow Control devices for loads control suited for C295 configuration and WT model</i> - Design of Flow Control devices - Manufacturing of the flow control devices - Installation of the Flow Control devices for loads control suited for C295 configuration and WT model	CATIA Files Memorandum	$T_0 + 18$
	D.1.4.2	CFD model of C295 including flow control concept - CFD simulations and predictive results - Assessment of the flow control against WTT - Post-test CFD simulation and correlation.	Reports Data files of models	$T_0 + 30$
WTT	D.1.5.1	WT Model Design - Baseline Model Design - New Flap, winglet and spoiler design - Power system for propellers design - Instrumentation and pressure taps on wing - Model Support	CATIA files Report Document	$T_0 + 8$
	D.1.5.2	WT Test Components manufacturing and integration - Model support - Balance - TPS's and propeller control - Rotating Shaft Balance (RSB) - Flow control devices	Report Document Data Files	$T_0 + 16$
	D.1.5.3	WT Test Campaigns for concepts development and assessment - Test Campaigns - Data provision and data analysis	Report Document Data Files	$T_0 + 20$

Table 4: Deliverables for the Flight Physics activities

Deliverables			
Ref. No.	Title - Description	Type	Due Date
D.2.1	Structural trade-offs and Manufacturing Processes - Analysis of architectural trade – off - Proposed materials and manufacturing processes	Report	$T_0 + 12$
D.2.2	Technical documentation supporting PDR - Structural Analysis - CATIA Models and drawings	Report Drawings	$T_0 + 18$
D.2.3	Technical documentation supporting CDR - Structural Analysis - CATIA Models and drawings	Report Drawings	$T_0 + 30$
D.2.4	Delivery of Parts and subassemblies for Full Scale Test - Parts ready for final assembly in Tests specimens - Quality inspection reports	Parts Reports	$T_0 + 39$
D.2.4	Delivery of External Wing Assembly for “on – ground” Wing demonstrator - Quality inspection reports	Assembly Reports	$T_0 + 39$
D.2.5	Delivery of Parts and subassemblies - Parts ready for final assembly in “in-flight” demonstrator - Quality inspection reports	Parts Reports	$T_0 + 39$
D.2.6	Delivery of External Wing Assembly for FTB2 installation - Quality inspection reports	Assembly Reports	$T_0 + 48$
D.2.7	Technical Documentation supporting Permit to Fly process with Airworthiness Authorities - Means of compliance	Reports	$T_0 + 50$

Table 5: Deliverables for the activities in Structures

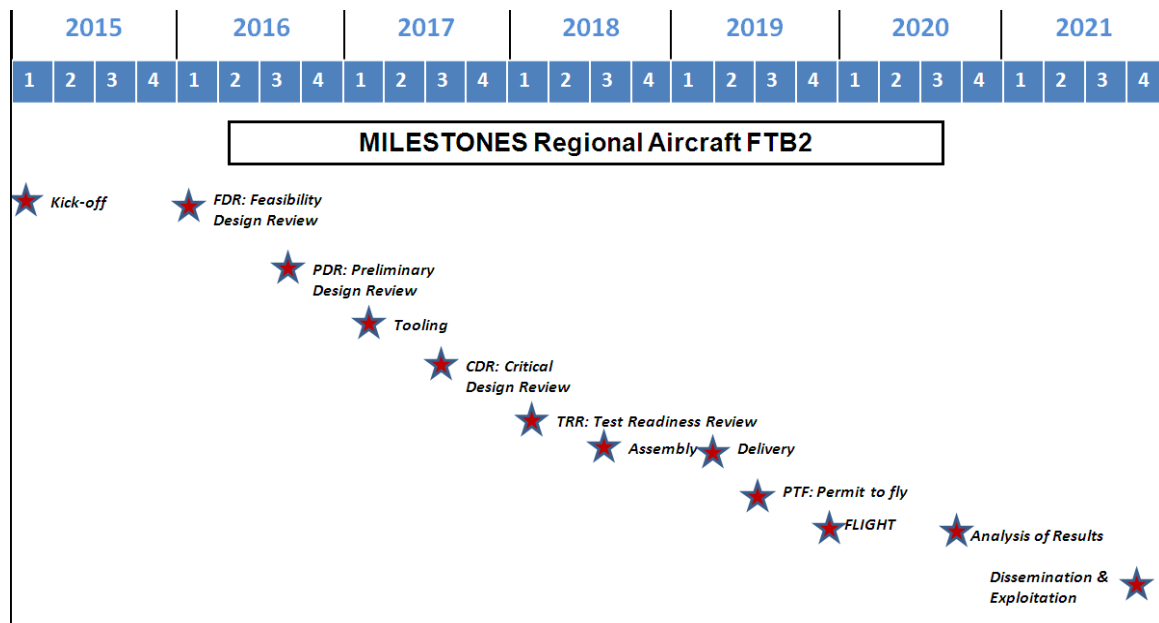


Figure 8: Milestones for the Regional Aircraft FTB2

Short and medium objectives and activities

The short terms activities in the Regional Aircraft FTB2 IADP are related to the general aircraft design. According to this Call for Core-Partner(s), all the activities in the Flight Physics domain start in 2015. The objectives within the first two years are:

- Regional Aircraft FTB2 Overall Aircraft Design: concepts definition and requirements
- Flight Physics Design of FTB2 components (flap, winglet and spoiler): including aero-shapes (simulation and tests), aircraft and components loads.
- Wind Tunnel activities to support Design of FTB2 components: model design, low speed tests and data analysis

Short term milestones are:

- Flight Physics Conceptual Design ($T_0 + 6$)
- Flight Physics Preliminary Design (1st loop) ($T_0 + 12$)
- WT model Design ($T_0 + 12$)
- WT model Manufacturing and Integration ($T_0 + 15$)
- WTT at low velocities ($T_0 + 18$)

5. Definition of terms

TRL	Technology Readiness Level	FEM	Finite Element Method
POA	Production Organization Approval	CAA	Computational Aero Acoustics
DOA	Design Organization Approval	WT	Wind Tunnel
EASA	European Aviation of Safety Agency	WTT	Wind Tunnel Tests
FAA	Federal Aviation Administration	WTM	Wind Tunnel Model
		RSB	Rotating Shaft Balance
LCA	Life Cycle Analysis	HPC	High Performance Computing
LCCA	Life Cycle Cost Analysis	FT	Flight Tests
OEM	Original Equipment Manufacturer	LC	Lift Coefficient
R&T	Research and Technology	DC	Drag Coefficient
GRA	Green Regional Aircraft	AoA	Angle of Attack
NDI	Non Destructive Inspection	HQ	Handling Qualities
MLA	Manoeuvre Loads Alleviation	FAR	Federal Aviation Regulations
GLA	Gust Loads Alleviation	TBC	To Be Confirmed
EMA	Electro Mechanical Actuator	TBD	To Be Defined
WAL	Work Area Leader	WBS	Work Breakdown Structure
CP	Core-Partner(s)	WP	Work Package
RH	Right Hand	FTB2	Flight Test Bed 2
LH	Left Hand	REG	Regional
IADP	Innovative Aircraft Demonstrator Platforms	EADS- CASA	Europeean Aeronautics Defense and Space – Construcciones Aeronáuticas S.A.
SPF	Super Plastic Forming	CTD	Capability and Technology Domain
ALM	Additive Layer Manufacturing	OAD	Overall Aircraft Design
OSD	One Shot Drilling	JTP	Joint Technical Programme
OSA	One Shot Assembly	CAD	Computed Aided Design
ITD	Integrated Technology Demonstrator	CFD	Computational Fluid Dynamics
JTP	Joint Technical Programme	PTF	Permit to Fly

Clean Sky 2 – Fast Rotorcraft IADP

I. LifeRCraft Airframe

Leader and Programme Area [SPD]	Airbus Helicopters - FRC IADP Compound Rotorcraft Demonstrator		
Work Packages (to which it refers in the JTP)	FRC 2.2.5 – Airframe Structure		
Indicative Topic Funding Value	7,5 M€		
Leading Company	Airbus Helicopters		
Duration of the action	5,5 years [until end of LifeRCraft demo flights]	Start Date	1 April 2015
Date of Issue	13/6/2014	Call Wave	1

Topic Number	Title		
JTI-CS2-2014-CPW01-FRC-02-01	LifeRCraft Airframe <i>Central and front fuselage sections - Design, Optimization, Manufacturing, V&V including airworthiness substantiation</i>	Duration	5,5 years
		Start Date	1 April 2015

Short description and terms of reference

The aim of the present topic is to design, manufacture and test a fuselage for the Compound Rotorcraft Demonstrator IADP LifeRCraft.

This fuselage should include trend setting manufacturing processes, innovative materials as well as an optimized design to meet the ecological challenges and to be sustainable for the environment, customers and industry.

The fuselage consists of a

- Main structure, (forward, center, rear fuselage)
- Structural provisions for Landing Gears (Nose LDG. Tandem LDG), Main Gear Box, Engine attachment, Tail interface
- Maintenance openings/covers
- Provisions for Doors and Cowlings
- Provisions for external equipment (Antennas, Search Lights, Radomes, etc.)
- Provisions for installation of sub-systems (i.e. fuel, wiring, avionics, etc.)
- Test articles on component level

The major lay-out principles are focusing on

- Light weight design
- Certifiable design (CS29 is the baseline, special conditions could be required – not yet defined)

- Aerodynamic performance (low drag)
- Dynamic behaviour influenced by the speed envelope, propeller and rotor interactions
- Ecological design principles

The fuselage will be assembled in the LifeRCraft Project with the tail structure and the wings, with the objective of bringing technologies to a Full Scale Demonstrator (full TRL6).

1. Background

The **LifeRCraft (IADP)** project aims at demonstrating that the compound rotorcraft configuration implementing and combining cutting-edge technologies as from the current Clean Sky Programme opens up new mobility roles that neither conventional helicopters nor fixed wing aircraft can currently cover in a way sustainable for both the operators and the industry. The project will ultimately substantiate the possibility to combine in an advanced rotorcraft the following capabilities: payload capacity, agility in vertical flight including capability to land on unprepared surfaces nearby obstacles and to load/unload rescue personnel and victims while hovering, long range, high cruise speed, low fuel consumption and gas emission, low community noise impact, and productivity for operators. A large scale flightworthy demonstrator embodying the new European compound rotorcraft architecture will be designed, integrated and flight tested.

In addition to the complex vehicle configurations, Integrated Technology Demonstrators (**ITDs**) will accommodate the main relevant technology streams for all air vehicle applications. They allow the maturing of verified and validated technologies from their basic levels to the integration of entire functional systems. They have the ability to cover quite a wide range of technology readiness levels.

2. Scope of work

This call for Core-Partner(s) encompasses all the activities needed for developing and manufacturing the Fuselage of the LifeRCraft Demonstrator as part of the Fast Rotorcraft IADP. Therefore, activities such as engineering, manufacturing and testing are included in this call along with the relevant management activities.

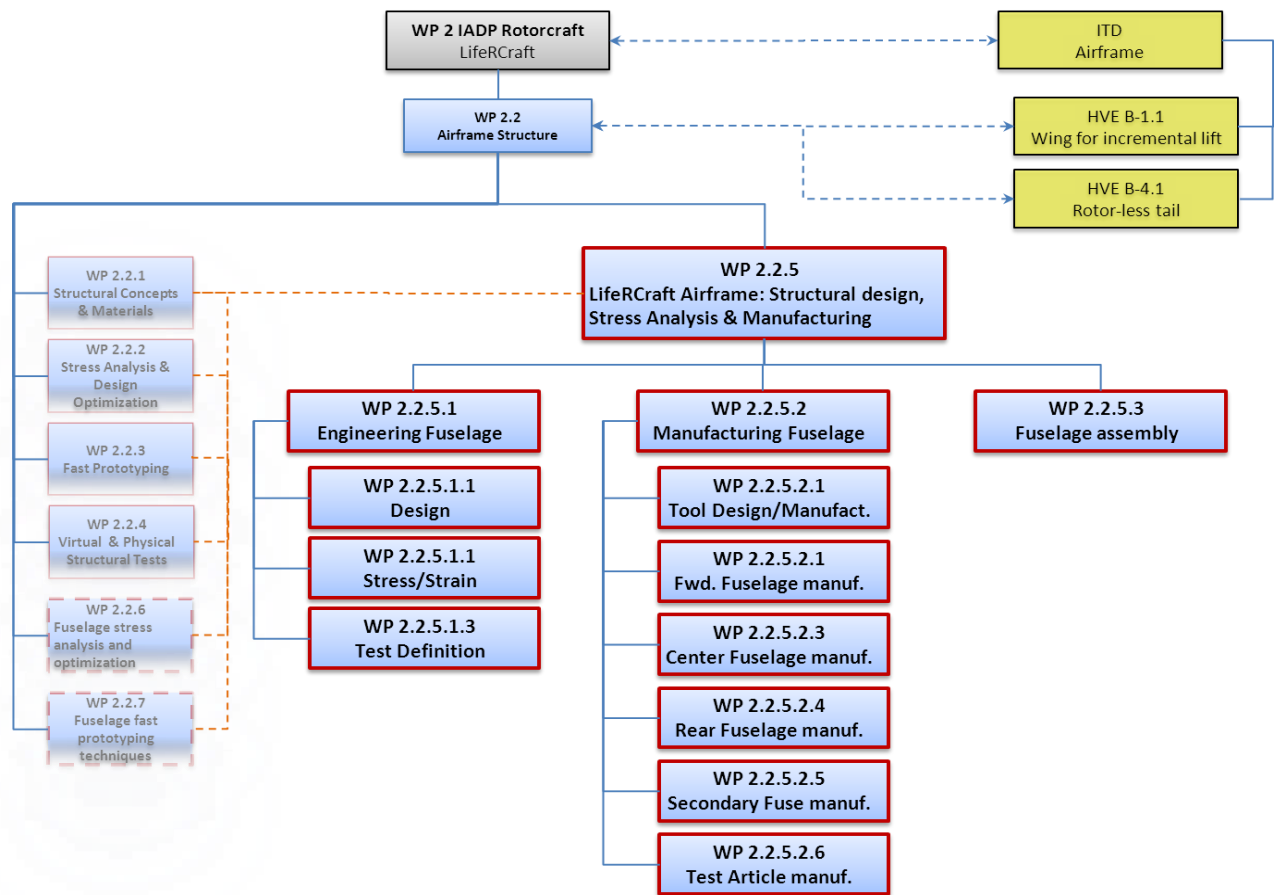
The overall Roles and Responsibilities of the Core-Partner are as follow:

- **Technical Activities:** He is the Design and Structural Manufacturing Responsible, therefore the tasks and the WPs in which, completely or partially, the Core-Partner(s) will work are (Built to Spec):
 - Development of the fuselage according to the specifications and interface definitions delivered by AH [WP 2.2.5.1]
 - Development of the structural concept (supported by AH)
 - Selection of materials and manufacturing processes (harmonized with AH)
 - Detailed lay-out and design
 - Substantiation concept (incl. tests)

- Contributing to permit to fly
 - Support to ground- and flight tests
- Manufacturing of all the Single Parts of the Fuselage [WP 2.2.5.2]
- Assembly of the fuselage [WP 2.2.5.3]
- **Managing and Coordination Activities:**
 - The Core-Partner(s) is (are) responsible as member(s) of the consortium according to the Grant Agreement documentation
 - Manage & Coordinate directly all the WPS for which he has full responsibility
 - Manage & Coordinate directly the activities related to WPs for doors (Pilot, Co-Pilot etc.) and Cowlings (MGB, engine, etc)
 - Launch, Manage and Coordinate all the CfP and CfT, into the framework of the Fuselage development.
 - Follow the Configuration Management process over entire program duration (details to be fixed during GAM-Phase)

As seen on the diagram below, the WBS of the Fuselage for LifeRCraft has been organised in accordance with the sub-work packages given in the JTP for the LifeRCraft Demonstrator WP 2.2 Airframe.

- WP 2.2.1 Structural Concepts & Materials
- WP 2.2.2 Stress Analysis & Design Optimization
- WP 2.2.3 Rapid Prototyping
- WP 2.2.4 Virtual & Physical Structural Test
- WP 2.2.5 LifeRCraft Airframe: Structural design, Stress Analysis & Manufacturing



The Scope of the work is to develop and manufacture a light weight fuselage for a fast rotorcraft (compound helicopter) along eco-design principles.

The fuselage comprises the following main structural elements and all structural sub-elements belonging to it:

- Forward Fuselage (Cockpit-section)
 - Forward Fuselage Structure
 - Mechanical interfaces to Centre Fuselage
 - Provisions for sub-systems (e.g. nose ldg. gear, antennas, doors, fairings, cabin-interiors, lightning protection, search light, position light, avionics, etc.)
- Centre Fuselage
 - Centre Fuselage Structure
 - Mechanical interfaces to Forward Fuselage, Wing, Rear Fuselage
 - Provisions for sub-systems (eg. wing attachment, main gear box, engines, control system items, cabin doors, fairings, covers, antennas, lightning protection, etc)
- Rear Fuselage
 - Rear Fuselage Structure
 - Mechanical interfaces to Centre Fuselage and Tail
 - Provisions for sub-systems (eg. fairings, covers, antennas, lightning protection, etc.)

Note: The design of the fuselage has to cope with the specific physical requirements caused by the innovative anti-torque concept as well as the requirements typical of a conventional Helicopter e.g:

- High vibration level
- Un-steady aerodynamic flow
- Flight speed from 0 to 235 kts (max speed in dive tbd)
- High thermal loading due to exhaust gases (mainly for rear fuselage)
- Un-symmetric propeller thrust
- Un-symmetric lift at the wings possible
- Lateral landing velocity possible
- Rolling take-off and landing
- Etc.

The work plan is structured into 4 phases. Project management will follow standard practices by applying reviews as PDR, CDR, TRR, QR etc.



Detailed description/content of the phases

The descriptions and details which will follow have been established under the assumptions that

- The selected Core-Partner(s) is (are) certified CS21 (DOA and POA).
- The selected Core-Partner(s) is (are) able to manufacture according to the quality requirements which are standard in the aeronautic industry (ref. Phase 3).
- If the above mentioned requirements are not satisfied, the certification of the partner according to CS21 has to be achieved 6 months prior to the delivery of the flyable parts at the latest. The acquisition of the certification has to be done under the partners own responsibility and at their own costs.

Phase 1

The main challenge during this phase is to satisfy all the requirements and boundary conditions for a high speed aircraft in ECO-design by designing a light weight and aerodynamically optimised structure. The recurring cost for a potential production also has to be addressed. The weight for the fuselage structure, including doors, fairings, maintenance doors and landing gear doors should not exceed 650 kg (preliminary target).

- The way of achieving these targets is under the responsibility of the Core-Partner(s) and includes the detailed design. Basic data regarding e.g. structural concept, loft, interfaces, etc. are under the responsibility of AH (GRS)

- the selection of the used materials (Ref. to chapter 3)
- the selection of the manufacturing and assembly process (Ref. to chapter 3)

Phase 1 comprises the **lay-out of the fuselage** and creating a set of **detailed drawings** and **substantiation documents** for the forward, centre and rear parts including all sub-elements (e.g. doors, fairings, supports, provisions...). This includes, but is not limited to:

- performing detailed design (limited common design office at AH facility)
- responsibility of reaching the weight targets
- responsibility of achieving recurring cost estimations
- responsibility of the structural layout and substantiation (static and dynamic)
- performing local loads distribution
- supporting aerodynamic design by ensuring the proper integration of single components
- selection of materials and processes (harmonized with AH, ref chapter 3)
- responsibility of the manufacturing tools design
- definition of test components
- definition of the tests to be done before flyable fuselage delivery (harmonized with AH)
- achieving and documenting data for life cycle assessment
- definition of inspection and repair methods (to be approved by AH)

Phase 1 will be based on the fuselage concept, the specifications and interface definitions from AH.

Several additional information sets (interface definition, external loads documentation, general requirement specification,...) prepared by AH will enable the partner to perform the task. A permanent support is envisaged.

In order to achieve a permit to fly, several harmonisation tasks and agreements have to be defined prior the start of phase 1. This comprises

- Engineering-Tool harmonisation (substantiation-tools defined by AH, IT, Programme management, configuration management)
- Quality assurance process harmonisation
- Communication management
- Dissemination of reports, technical documentation (e.g. substantiation documentation, test results, quality documentation, etc.)
- Modus vivendi of access rights for general documentation, information, quality reports, ...
- Co-development phase

Phase 2

Phase 2 will consist on the manufacturing of test parts and the demonstrator fuselage.

Based upon the outputs of Phase 1, the hardware will be manufactured according to agreed material

and tool selection.

The Fuselage has to be assembled, checked for compliance with design. Functionality tests have to be performed for fairings, supports, doors etc.. The appropriate documentation has to be provided along with a compliance matrix.

Depending on the request of the ITD Airframe/Wing, sub-structural elements (e.g. Wing attachment elements) could also have to be manufactured by the Core-Partner(s).

Phase 3

This phase is dedicated to meeting requirements for the LifeRCraft to obtain a “permit to fly”.

Since AH is the responsible in front of the airworthiness agency, Ah needs full support in this endeavor by the Core-Partner(s).

Therefore, the main task of this phase is to contribute to the AH activities by supporting/delivering:

- Documentation to support AH in the process to obtain a permit to fly
 - Substantiation documentation for stress/fatigue/dynamic, vibration and bird strike
 - Documentation for *flightworthiness* according to a *flight condition approval plan* (basis for flightworthiness are CS29 + special conditions (not yet defined)
 - Tests reports(entire test-pyramid)
 - Quality documentation for the delivered structural elements
 - Quality methods substantiation documentation

Note: As the permit to fly documentation has to be endorsed by AH CVE's, a harmonization process with AH of respective documentation has to be forecasted

- General Behavior of the fuselage (rigidity, deflection, etc....)
- Description of applied manufacturing processes

This phase includes the tests to be performed by the Core-partner(s) at the components' level (or sub-components) to contribute to the permit to fly

Phase 4

This phase has two major tasks:

1. Ground integration tests

Tests performed to check the satisfactory behavior of the fuselage integrated with other aircraft components. The goals are to support the substantiation process, to demonstrate the achieved level of safety and to get the necessary data for analyzing the forecasted tests results. The delivered articles will incorporate the necessary test instrumentation;

2. Flight tests to demonstrate the successful achievement of the CS2-project objectives.

The delivered articles will incorporate the necessary flight test instrumentation.

Both test-phases conducted by AH needs the support of the Core-partner to ensure a direct link and reactivity in case of malfunctions, defects, improvements needed etc.

Project synthesis

The Core-Partner(s) has (have) to participate and provide input to the project synthesis. It particularly regards drawing the lessons learned from the demonstration evaluation, supporting the technical evaluation process (including Eco-design aspects) and participating in the evaluation of characteristics for a commercial product.

The above mentioned requirements and the IP process will be fixed in more details during the partner agreement phase.

3. Special skills, capabilities

Requirements needed to achieve a permit to fly:

- Provide material data which are required to achieve a permit to fly
- Use material, processes, tools, calculation tools etc. which are commonly accepted in the aeronautic industry and certification authorities.
- Harmonize (AH-Core-Partner(s)) calculation processes/tools
- Interact with AH at any stage of the work
- Access to the production sites
- Achieve TRL 4 for each system/technology proposed in 2015 at the latest. If not achieved on time, Core-Partner (s) is (are) expected to initiate a mitigation plan in order to reach the target of TRL 6 at the end of demonstration.
- Perform updates of documentation in case of insufficient content for authorities.

Special Skills

- Experience in design and manufacturing of structures in non-conventional and conventional composite materials (thermoset and thermoplastic plus high temperature systems) and innovative metallic components. (M)
- Capacity to assemble composite and metallic parts (aluminium, titanium ...);with hybrid joints.
- Design, analysis and configuration management tools of the aeronautical industry (i.e. CATIA v5 release 21, NASTRAN, VPM) (M)
- Competence in management of complex projects of research and manufacturing technologies. (M)
- Experience with TRL Reviews or equivalent technology readiness assessment techniques in research and manufacturing projects for aeronautical industry (M)

- Proven experience of collaboration with reference aeronautical companies in industrial air vehicle developments, therefore showing “in – flight” components experience.(M)
- Experience of collaborating with industrial partners, institutions, technology centres, universities and OEMs (Original Equipment Manufacturer) within international R&T projects.(A)
- Capacity of providing large aeronautical components within industrial quality standards.(M)
- Capacity to support documentation and means of compliance to achieve experimental prototype “Permit to Fly” with Airworthiness Authorities (i.e. EASA, FAA and any others which may apply).(M)
- Experience in technological research and development in the following fields:
 - o Innovative processes in composite materials (i.e. thermoset, ISC thermoplastic, thermo-forming, In-Situ Co-consolidation with no-welding, Out of Autoclave technologies).(M)
 - o High Temperature Materials for Structural Applications, 135°C and more.(M)
 - o Highly integrated structures (i.e. production rate, cost, and weight savings) (M).
 - o Assembly (when applicable).
 - o Process automation.(A)
- Capacity to specify material and structural tests along with the design and manufacturing phases, such as material screening or panel type tests and instrumentation. (M)
- Capacity to perform structural and functional tests of large aeronautical components: test preparation and analysis of results (M)
- Capacity to repair components in shop to correct manufacturing deviations.(M)
- Capacity to support the global aircraft Configuration management.(A)
- Capacity of performing Life Cycle Analysis (LCA) and Life Cycle Cost Analysis (LCCA) of materials and structures.(A)
- Capacity of evaluating results in accordance with Horizon 2020 environmental and productivity goals following Clean Sky 2 Technology Evaluator rules and procedures.(A)
- Capacity of evaluating design solutions and results with respect to IAW Eco-design rules and requirements all along the project.(M)
- Design Organization Approval (DOA).(M)
- Product Organization Approvals (POA).(M)
- Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004) (M)
- Regulated facilities for the use of laser in manufacturing processes.(A)
- Qualification as Material and Ground Testing Laboratory of reference aeronautical companies (i.e. ISO 17025 and Nadcap).(M)
- Qualification as strategic supplier of structural test on aeronautical elements.(A)
- Technologies for composite manufacturing with OoA processes: e.g. RTM, Infusion, SQRTM Thermoforming, Roll-forming (M)

- Metallic manufacturing (A), including Additive Layer Manufacturing (A)
- Mechanical processes, in both composite material and metallic. Hybrid joints (CFRP + Metal) (M)
- Automatic Thermoplastic laying and In-situ Co-Consolidation equipment (A)
- Automated manufacturing process (i.e. Automated Fiber Placement, Automated Tape Lay-up, Dry Fibre pre-forming) (A)
- Manual composite manufacturing: hand lay-up (M)
- Assembly jigs and assembly process definition.(A)
- Tooling design and manufacturing for composite components.(M)
- Autoclaves and ovens (temperatures above 400 °C) as back-up solutions of composite components (parts of Φ 2m and 6m) (A)
- Advanced Non Destructive Inspection (NDI) and large components inspection to support new processes in the frame of an experimental Permit to Fly objective: (M)
 - o Dimensional and shaping inspections
 - o Morphology studies of materials
 - o Ultrasonic inspection capabilities
 - o Additional NDI will be welcomed i.e.: Infrared (IR) Thermography, Laser Shearography, Laser ultrasonic inspection, X – ray Computed Tomography (XCT), ...
- Contactless dimensional inspection systems
- Simulation and Analysis of Tolerances and PKC/AKC/MKC (Product, Assembly and Manufacturing Key Characteristics) (A)

M=Mandatory; A= Appreciated

Material and Processes

In order to reach the main goals of the project, the two major aspects of maturity and safety have to be considered for materials and processes.

Because of the ambitious plan to develop a flying prototype in a short time frame, the manufacturing technology of the Core-Partner(s) must be at a high maturity level (TRL4) to safely reach the required technology readiness for the flying demonstrator.

To secure this condition, the Core-Partner(s) will have to demonstrate the technology readiness for his proposed materials and process and manufacturing technology with a TRL review, to be held together with AH.

The TRL review must be held within one year after the beginning of the project and must confirm a maturity of TRL5 (or at least TRL4 if a solid action plan to reach TRL5 within the scope of one further year is validated and accepted by AH).

Furthermore, the schedule of the project and the budget framework do not allow for larger unanticipated changes after the middle of the project. Therefore, it is required that, at the start of

the activities, the Core-Partner(s) demonstrates his capability to develop and manufacture the required items with a baseline technology (which can be e.g. Prepreg, RTM or lightweight Aluminium) as a back-up solution in case the new technology introduced proves to be too challenging.

This back-up plan, which is made to secure the accomplishment of the project goals shall be agreed between AH and the Core-Partner(s) within half a year after the start of the activities.

Furthermore the M&P activities in the IADP and Airframe ITD shall support the safe inclusion of the Core-Partner(s) technology into the complete H/C.

Certification:

- Design Organization Approval (DOA).
- Product Organization Approvals (POA).
- Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004)
- Qualification as Material and Ground Testing Laboratory of reference aeronautical companies (i.e. ISO 17025 and Nadcap).
- Qualification as strategic supplier of structural test on aeronautical elements.

General requirements on the fuselage

Main functions:

Support the wing, the transmission (with MGB suspension), the engine (fire-wall), and the tail

Include (part of WP):

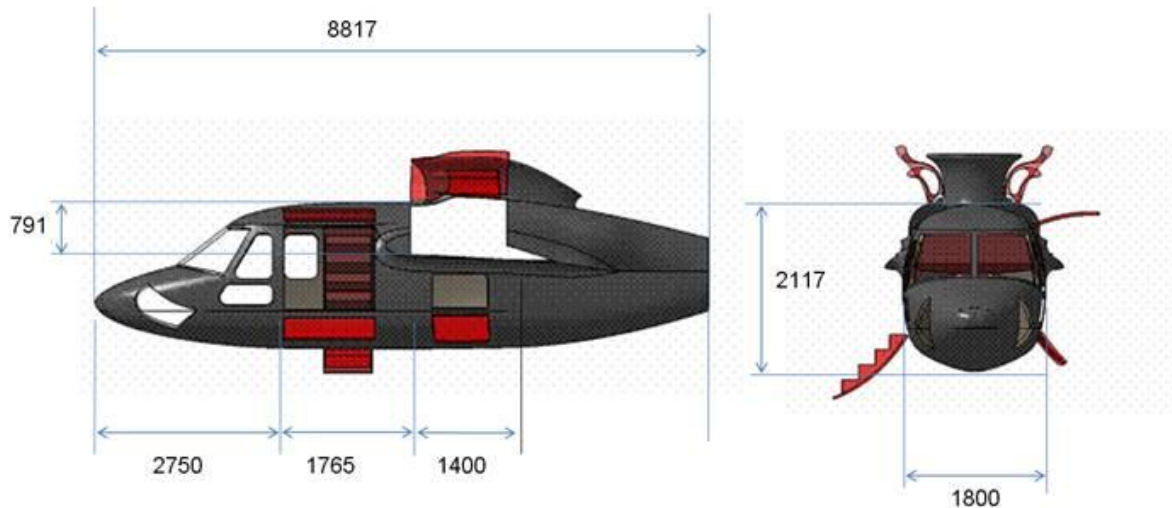
- Landing gear doors
- Doors (could be separated WP):
 - Passengers
 - Maintenance doors
 - ...
- Cowlings (could be separated WP)
- Upholstery with acoustic insulation capability (could be separated WP)
- Transparencies: (could be separated WP)
 - Windshield: anti-icing, bird strike, wiper-washer (TBC)...
 - Lateral windows: acoustic insulation

Integration of (components not part of WP):

- Cockpit with crew seats, display panel, control panels
- Flight control
- Retractable LG: main and nose (not part of fuselage)
- Fuel storage and engine supply
- ECS
- Avionics equipment's/electrical systems
- Cabin accommodation
- Integration of active vibration control system
- position lights

Main functions (cont'd):

- Provision for:
 - Radio antennas
 - Mission equipment's (weather, EOS, rescue hoist...)
 - Search light(s)
 - Emergency floatation
- General requirements:
 - Bird strike for canopy
 - Lightning strike (direct & indirect)
 - EMI protection
 - Light weight
 - CS29 + special conditions
 - ECO Friendly materials & processes
 - Quality in accordance to a serial product



Weight

The target is to obtain the lowest weight possible for the proposed component compliant with the technical requirements and compatible with a serial aeronautical production.

In its offer, the applicant(s) shall provide an estimated maximum weight of its proposed component. This value will be updated for the signature of the consortium agreement regarding the design data available at this time. The difference with the weight provided with the offer will be substantiated and the new weight figure will have to be agreed with the leader

For the PDR, the core-partner will have to provide a detailed weight breakdown of the component in accordance with the technology, the technical requirement and the interfaces agreed with the leader. The difference with the weight agreed in the consortium agreement will be substantiated and submitted to the approval of the leader.

For the CDR, the Core-partner will provide an update of the weight breakdown with a substantiation of the difference with the PDR version. If an update of the overall weight is necessary, it will be submitted to the approval of the leader.

The components for the flying demo will be delivered with a weight record sheet and deviations from the target agreed during CDR will be substantiated.

At the end of the demonstration phase, the core-partner will provide a weight estimation of the component for serial production in accordance with the lessons learned during the demo phase. Differences from CDR weight have to be explained.

Recurring cost estimation

The target is to obtain the optimum between the level of performances of the Fast rotorcraft and the cost of the potential product.

For the PDR, the core-partner will provide an estimation of the recurring cost of the component on the basis of the assumptions given by the leader. An up-date will be provided for CDR and at the end of the demonstration phase.

External shape

To maintain the overall drag of the fast rotorcraft at a low value is a strong challenge for the fast rotorcraft demonstrator. The external shape will be provided by the leader (3D CATIA model V5 R21). This shape is subject to change during the demonstration process after CFD analysis and/or wind tunnel tests. If changes are deemed necessary after the PDR, a retrofit solution of the demonstrator parts will be defined in accordance with the leader. Each change of the external shape requested by the core-partner has to be agreed by the leader.

Data management

The leader will use the following tools for drawing and data management:

JET (ISAMI)

CATIA V5 R21

VPM compatible

SAP compatible

The partner will provide interface drawings and 3D model for digital mock-up in CATIA V5. The data necessary for configuration management have to be provided in a format compatible with VPM tool.

Core Partner Topic		2014	2015	2016	2017	2018	2019	2020
Core Partner Scope of Work	LifeRCraft IADP	Gen. Specs. inputs	KoM		4	TRAPF		Final Demo Review
	Phase 1 Layout & Design							
	Phase 2 Manufacturing of test parts & demonstrator fuselage							
	Phase 3 Contribution to Permit to Fly		PDR		CDR			
	Phase 4 Support to ground & flight tests							
Airframe ITD platform						5		

4. Major deliverables and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type	Due Date
FRC2.2.5-D1	Structural trade-offs and Manufacturing Processes for LifeRCraft Fuselage - Analysis of architectural trade – off - Proposed materials and manufacturing processes	Report	T0 + 04&09
FRC2.2.5-D2	Technical documentation supporting PDR of LifeRCraft Fuselage - Structural Analysis solutions - CATIA Models and drawings of solutions -Weight breakdown and associated substantiations - Recurring Cost estimation	Report Drawings	T0 + 09
FRC2.2.5-D3	Technical documentation supporting CDR of LifeRCraft Fuselage - Structural Analysis solutions - CATIA Models and drawings of solutions - Weight breakdown and associated substantiations - Recurring Cost estimation	Report Drawings	T0 + 21
	Delivery of Parts and subassemblies(if apply) of LifeRCraft fuselage for test purposes. - Quality inspection reports	Parts Reports Drawings	T0 + 30
FRC2.2.5-D4	Delivery of Parts and subassemblies of LifeRCraft Fuselage - Parts ready for final assembly in “in-flight” Demonstrator - Weight assessment - Quality inspection reports	Parts Reports Drawings	T0 + 33
FRC2.2.5-D5	Technical Documentation supporting Permit to Fly process with Airworthiness Authorities - Means of compliance	Reports Drawings	T0 + 39
FRC2.2.5-D6	Analysis of flight tests results and estimation of the characteristics of a serial product including the demo lessons learned	Reports Drawings	T0 + 63

5. Definition of terms

AH	Airbus Helicopters
CDR	Critical Design Review
CfCP	Call for Core-Partner(s)
CfP	Call for Partner
CfT	Call for Tender
CI	Configuration Items
CP	Core-Partner(s)
CSxy	Certification Specifications
DOA	Design Organization Approval
EMI	Electro Magnetic Interference
GAM	Grant Agreement for Members
GRS	General Requirement Specification
HTP	Horizontal Tail Plane
HVE	High Versatility and Cost Efficiency
IAW	In Accordance With
JTP	Joint Technical Proposal
LCA	Life Cycle Analysis
LG	Landing Gear
LifeRCraft	Low Impact Fuel Efficiency RotorCraft
PDR	Preliminary Design Review
PGB	Propeller Gear Box
POA	Product Organization Approval
QR	Qualification Review
RR	Roles and Responsibilities
TRL	Technology Readiness Level
TRR	Test Readiness Review
WAL	Work area Leader
WBS	Work Breakdown Structure
WP	Work Package

II. LifeRCraft Drive System

Leader and Programme Area [SPD]	FRC : Mechanical drive system for LifeRCraft		
Work Packages (to which it refers in the JTP)	WP 2.6.9		
Indicative Topic Funding Value	6,5 M€		
Leading Company	Airbus Helicopters		
Duration of the action	Until the end of LifeRCraft demo (delivery of flightworthy components, and follow-on during the demo phase)	Start Date	1 April 2015
Date of Issue	13/6/2014	Call Wave	1

Topic Number	Title		
JTI-CS2-2014-CPW01-FRC-02-02	LifeRCraft Drive System <i>Main Gear Box input modules and equipped Propeller Gear Boxes - Design, Optimization, Manufacturing, V&V including airworthiness substantiation</i>	Duration	5,5 years
		Start Date	1 April 2015

Short description

The aim of the present topic is to design, manufacture, test and support part of Drive System for the Compound Rotorcraft Demonstrator IADP LifeRCraft.

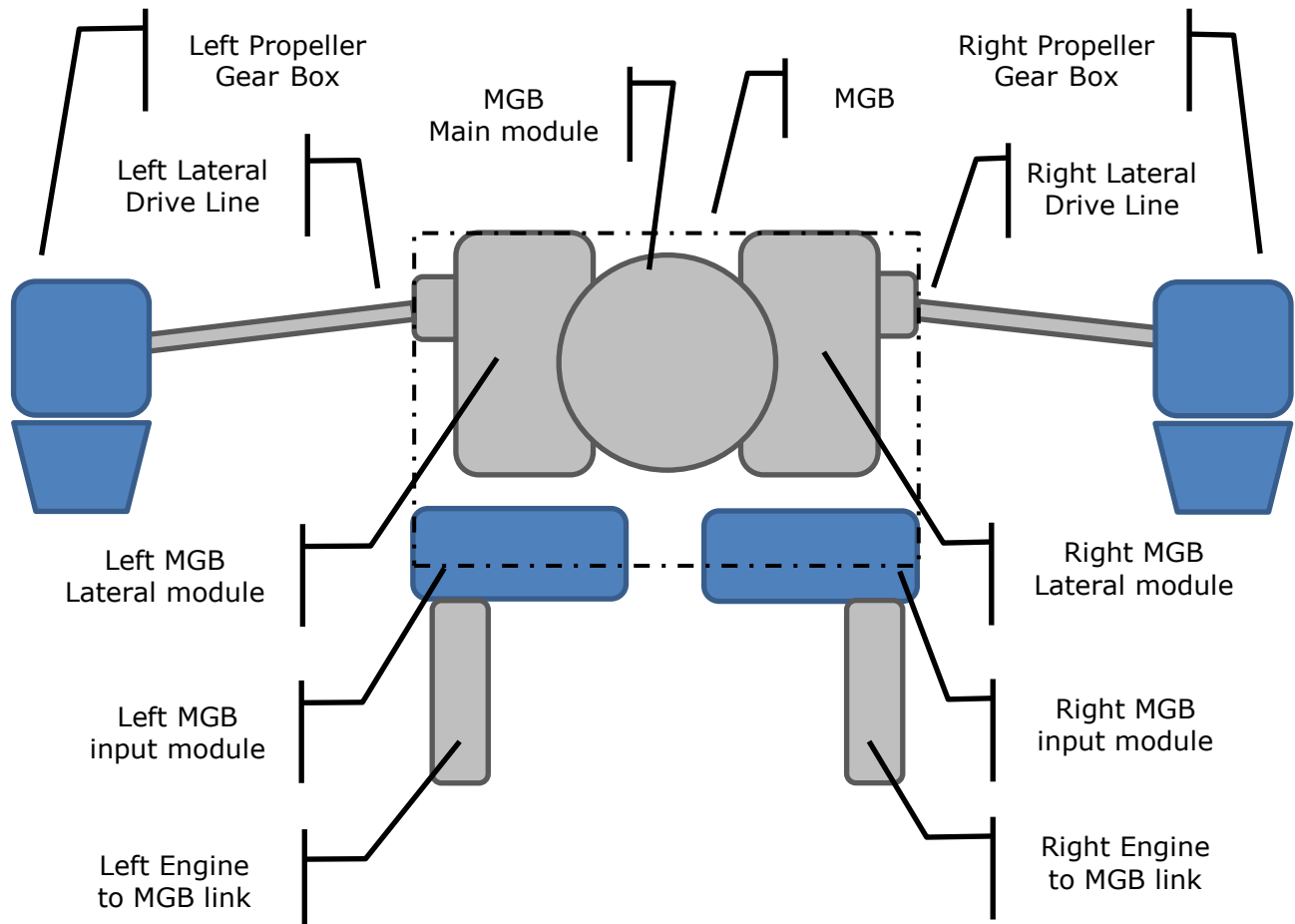
This drive system should include an optimized design to meet the ecological challenges and to be sustainable for environment, customer and industry.

The drive system could include innovative designs, trend setting manufacturing processes, innovative materials but if the TRL of each innovation is lower than 4 in 2015 and if it is risky for the program, a conventional solution must be provided and might be implemented as a back-up.

The Drive system consists of:

- Two Engine to MGB link (Left and Right)
- A Main gearbox constituted of:
 - Two input modules (left and right)
 - Two lateral modules (left and right)
 - Main module
- Two lateral Drive line (left and right)

- Two propeller gearbox (left and right).



Rotorcraft Demonstrator IADP LifeRCraft Drive system scheme

IMPORTANT:

The following items are out of the scope of this Core-Partner(s) call (in grey on the sketch):

- Two Engine to MGB link (Left and Right)
- Two lateral Drive line (left and right)
- Two lateral modules (left and right)
- MGB Main Module

The major lay-out principles are focusing on

- Light weight design
- Performances and Reliability of the drive system
- Limited Power losses

- Drive system Monitoring
- Certifiable design (CS29 is the baseline)
- Limited and easy maintenance and support of drive system (Part and Assemblies installation/Removal, maintenance tasks etc...)
- Dynamic behaviour influenced by drive system rotation speed range

1. Background

The **LifeRCraft (IADP)** project aims at demonstrating that the compound rotorcraft configuration implementing and combining cutting-edge technologies as from the current Clean Sky Programme opens up new mobility roles that neither conventional helicopters nor fixed wing aircraft can currently cover in a way sustainable for both the operators and the industry. The project will ultimately substantiate the possibility to combine in an advanced rotorcraft the following capabilities: payload capacity, agility in vertical flight including capability to land on unprepared surfaces nearby obstacles and to load/unload rescue personnel and victims while hovering, long range, high cruise speed, low fuel consumption and gas emission, low community noise impact, and productivity for operators. A large scale flightworthy demonstrator embodying the new European compound rotorcraft architecture will be designed, integrated and flight tested.

In addition to the complex vehicle configurations, Integrated Technology Demonstrators (**ITDs**) will accommodate the main relevant technology streams for all air vehicle applications. They allow the maturing of verified and validated technologies from their basic levels to the integration of entire functional systems. They have the ability to cover quite a wide range of technology readiness levels.

This CfCoP is part of the **LifeRCraft compound rotorcraft demonstrator (FRC IADP)** and is managed in the Work package 2.6 “Mechanical Drive system”

2. Scope of work

The subject of topic relates to all the activities needed to design, develop, and support the LifeRCraft Demonstrator Drive system as described above. Therefore activities such as, technical assessments, design, manufacture and test will be necessary to perform into the scope of this call. Additionally to these Technical activities that will be described further it also described the managing activities that as Core-Partner should be performed by it - always in accordance with the Strategic Topic Manager.

Following are listed the subjects in which the Core-Partner(s) will perform its activities, under the following Roles and Responsibilities:

- **Technical Activities:**

The Core-Partner(s) roles and responsibilities will be: Design, Development and Support Responsible. Therefore the WPs and the tasks in which the Core-Partner(s) will work are:

- Subject 2.6321 MGB Input Module (Left and Right):

This WP consists of designing, developing and supporting a reduction stage of the MGB. This stage should be identical for both sides and is mainly constituted of helical gears, bearings, housings and part of lubrication system. The interface with environment (Engine to MGB link and MGB) of the Input module will be fixed with all others requirements in a specification supplied by AH after project start. The achievement of the WP in compliance with the specification will be done through the following tasks:

Phase 1:

- Task : Project (global 3D view and sizing)
- Task : Interface drawings
- Task : Detailed Studies
- Task : Parts (or system) substantiation (calculation)
- Task : Global FEM (for loads share and deflexions)
- Task : Specifications, follow up, choice of equipment
- PDR (milestone review)

Phase 2:

- Task : Drawing set
- CDR (milestone review)

Phase 3:

- Task : Kit manufacturing and assembly
- Task : Tests requests (development, flight clearance, flight)
- Task : Drawing kit (development, flight clearance, flight)
- Task : Test Realization and Follow up (development, flight clearance, flight)

Phase 4:

- Task : Conclusion to test (development, flight clearance, flight)
- Task : Modification studies following development test results
- Task : Drawing set modification
- Task : Manufacturing of modified parts and assemblies.

Phase 5:

- Task : flight clearance complete file (certification plan, limitations, directives, FMECA, maintenance doc)

Phase 6:

- Task : Support for parts manufacturing, parts assembly,

IMPORTANT: Number of kits needed by AH for the whole system integration and demonstration is as follows:

- 2 Input modules for flight / 1 spare for flight
- 2 for drive system integration tests and flight clearance

Other kits as may be necessary for development tests and fatigue tests to be performed by the Core-Partner(s) including corresponding spare parts have to be proposed by the candidate.

○ Subject 2.653 Propeller Gearboxes (Left and Right)

This WP consists of designing, developing and supporting propeller gearboxes. Those gearboxes are mainly constituted of bevel gears, bearings, housings, monitoring system, lubrication system (pump, sprayings etc..), lubrication cooling system, equipment support etc.... The interface with environment (wing, lateral drive line, propeller, hydraulics etc...) of propeller gearboxes will be fixed with all others requirements in a specification supplied by AH after project start. The achievement of the WP in compliance with the specification will be done through the following tasks:

Phase 1:

- Task : Project (global 3D view and sizing)
- Task : Interface drawings
- Task : Detailed Studies
- Task : Parts (or system) substantiation (calculation)
- Task : Global FEM (for loads share and deflexions)
- Task : Specifications, follow up, choice of equipment
- PDR (milestone review)

Phase 2:

- Task : Drawing set
- CDR (milestone review)

Phase 3:

- Task : Tests requests (development, flight clearance, flight)
- Task : Kit manufacturing and assembly
- Task : Drawing kit (development, flight clearance, flight)
- Task : Test Realization and Follow up (development, flight clearance, flight)
- Task : Conclusion to test (development, flight clearance, flight)

Phase 4:

- Task : Modification studies following development test results
- Task : Drawing set modification
- Task: Manufacturing of modified parts and assemblies.

Phase 5:

- Task : Flight clearance complete file (certification plan, limitations, directives, FMECA, maintenance doc)

Phase 6:

- Task : Support for parts manufacturing, parts assembly,

IMPORTANT: Number of kits needed by AH for system integration and demonstration is as follows:

- 2 Input modules for flight / 2 spare for flight
- 2 for drive system integration tests and flight clearance

Other kits as may be necessary for development tests and fatigue tests to be performed by the Core-Partner(s) including corresponding spare parts have to be proposed by the candidate.

- Subject 2.630 Drive system integration and tests
- This WP consists of following and supporting integration and tests activities not done in Core-Partner(s)' facilities. The achievement of the WP will be done through the following tasks:

Phase 7:

- Task : To manage and support tests (interfaces validation, Test requests, Kit drawings, tests preparation meetings, bench check and validation etc..) that should be done on other bench rigs and on systems designed by other companies (AH included)

Phase 8:

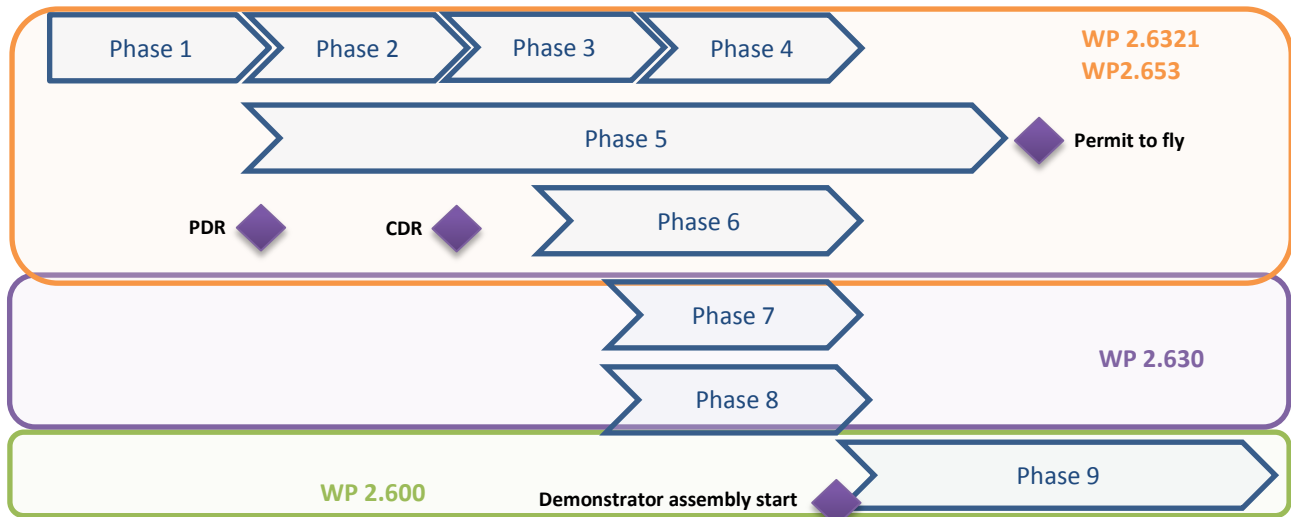
- Task: To define the specific flight monitoring system that will be needed to support the flight demonstrator.
- WP 2.600 Follow up of demonstrator during flight tests
This WP consists of following and supporting the flight demonstrator all along its flight tests campaign. The achievement of the WP will be done through the following tasks:

Phase 9:

- To give solutions to assembly issues on flight demonstrator.
 - To give solutions to technical problems (by analysis of flight test parameters) encountered during ground/flight tests (and if necessary by managing partners)
 - Task : Incidents in development solving (PPS)
 - to give instructions and approve done work on aircraft quality folder
- **Managing and Coordination Activities**
 - The Core-Partner(s) will:
 - Manage & Coordinate directly all the WPs that it will be fully responsible for
 - Share the WPs reporting work for the follow up with AH for the overall project development.
 - Follow the Configuration Management process via VPM or Winchill (tbc) over the entire program duration (details to be defined during project coordination phase prior start)

The work plan is structured into phases which are concluded with deliverables and milestones.

Project management will follow standard practices by applying reviews as PDR, CDR, TRR etc.



Core Partner Topic		2014	2015	2016	2017	2018	2019	2020
LifeRCraft IADP		Gen. Specs. inputs	Delivery to Assembly line	PDR	CDR	TRIP-IF	delivery for demonstrator	Final Demo Review
Core Partner Scope of Work	Phase 1 and 2 Layout & Design							
	Phase 3 Manufacturing of test parts & tests							
	Phase 4 modifications							
	Phase 5 Contribution to Permit to Fly							
	Phase 6 Manufacturing and assembly support							
	Phase 7 Integration tests							
	Phase 8 specific monitoring definition for demonstrator							
	Phase 9 Support to ground & flight tests							

Detailed description/content of project phases

The descriptions and details which will follow have been established under the assumptions that

- The selected Core-Partner(s) is (are) certified CS21 (DOA and POA) and familiar with the rules and requirements applicable in the aeronautic industry or at least the leading industrial partner within the cluster has to fulfil these requirements and take over full responsibility for airworthiness.
- The selected Core-Partner(s) is (are) able to manufacture according to the quality requirements which are standard in the aeronautic industry (ref. Phase 3).
- If the above mentioned requirements are not satisfied, the certification of the partner according to CS21 has to be achieved at the latest 6 months prior to the delivery of the flyable parts. The acquisition of data and test results and production of compliance evidence needed to obtain a Permit to Fly has to be performed under the Core-Partner(s)' own responsibility and included in its cost estimate.

Phase 1

This phase will enable to settle all data necessary to reach the specification requirements. The main challenge is to satisfy all the requirements and boundary conditions for a high speed rotorcraft by designing several essential and specific elements of its drive system. Recurring cost for a potential production have also to be addressed. The weight for Propeller Gear Boxes and Input Modules including cooling and lubrication systems should not exceed certain target values as indicated in the general requirements further below.

The way how to achieve these targets is under the responsibility of the Core-Partner(s).

At the end of Phase 1 the following topics have to be addressed for the PDR:

- System specification & associated compliance matrix
- Detailed System description (functional, technological (material, protection, coating) etc...)
- Interfaces status
- Equipment status
- Documentation list and status
- Development test plan
- Performance & limitations (SLL, TBO etc..)
- Weight breakdown (see NOTE below)
- RC, DMC
- Digital Mock Up status
- Drawings baseline
- Electrical network compatibility
- Procurement and Industrial status
- Delivery to test means
- Preliminary certification basis & plan
- Preliminary safety & reliability analysis
- Preliminary supportability (including maintainability & testability) analysis
- Critical parts list
- Risk and opportunity analysis
- Updated synthetic schedule

Phase 1 comprises a set of **study drawings** and **substantiation documents** for the whole system. This includes, but is not limited to:

- performing architecture/structural layout (common design office with AH)
- performing detailed studies
- Performing static and dynamic substantiation for parts and system (by calculation)
- Performing finite element models for loads share and deflections.
- Performing a logic test plan to be done (on parts and system) before delivery (harmonized with AH)
- Performing Critical part list

- Performing Certification plan
- responsible to achieve the specification targets (SLL)
- selection of material and process (harmonized with AH)
- responsible for manufacturing-tool design
- definition of inspection- and repair methods
- etc...

An AH support could be envisaged.

In order to achieve a permit to fly, several harmonisation tasks and agreements have to be defined prior the start of phase 1. This comprises

- Tool harmonisation (substantiation, IT, Programme management, configuration management, ..)
- Quality assurance process harmonisation
- Communication management
- Dissemination of reports, technical documentation (e.g. substantiation documentation, test results, quality documentation, etc.)
- Modus vivendi of access rights for general documentation, information, quality reports, ...
- Co-development phase

Phase 2

This Phase will achieve the detailed drawings of the parts, the equipment, the equipped parts and assemblies of the whole system.

Phase 2 comprises a complete **drawing set** for the system

At the end of this phase the following topics have to be addressed for the CDR:

- System specification & associated compliance matrix update
- Detailed System description (functional, technological (material, protection, coating) etc...) update
- Interfaces status update
- Equipment status update
- Documentation list and status update
- Development test plan update
- Performance & limitations (SLL, TBO etc..) update
- Drawings set status
 - Parts
 - Equipped parts
 - Assemblies
 - Equipment
- Weight breakdown update
- RC, DMC update
- Digital Mock Up status update

- Electrical network compatibility update
- Procurement and Industrial status update
- Delivery to test means update
- Preliminary certification basis & plan update
- Preliminary safety & reliability analysis update
- Preliminary supportability (including maintainability & testability) analysis update
- Critical parts list update
- Risk and opportunity analysis update
- Updated synthetic schedule update

Phase 3

This phase is dedicated to tests and kits manufacturing.

All test requests have to be prepared in accordance with the development test plan.

They should cover tests necessary for system development on bench, for flight clearance and for flight. All the necessary data have to be detailed into the test requests to define:

- The goal of the test
- The tested hardware
- The servitude hardware
- The test means
- The test program
- Successful test criteria
- The expertise and controls to be done before and after test.

Drawings kits, corresponding to dedicated test request, have to be released to be manufactured.

All tests have to be followed. A report of the test has to be issued.

Each test has to be answered by design office conclusion.

Phase 4

Following the phase 3 results, some modifications can be mandatory. This is the aim of phase 4.

All data from previous phases (results from design phase and from tests etc...) have to be collected and summed up. Thus, all necessary modifications can be synthetized and substantiated.

Phase 4 comprises a complete **drawing set update** for the system and a substantiation file for each modification.

Phase 5

This phase is dedicated to achieve a “permit for fly”. Baseline regulation is CS29.

LifeRcraft will be a flying demonstrator vehicle and therefore has to meet certain requirements to achieve a permit to fly. AH is the responsible in front of the airworthiness agency, and it is mandatory that AH will be supported by the Core-Partner(s). Therefore the Core-Partner(s) has to provide all documentation necessary to achieve permit to fly:

The main tasks are to contribute to the AH activities by delivering:

- Documentation in the process to achieve permit to fly
 - o System Description document
 - o System F.H.A. and F.M.E.C.A.
 - o Substantiation documentation for stress/fatigue
 - o System Maintenance document
 - o System limitations document
 - o Directives to be applied for the system
 - o Program/Reports/documentation of performed tests (entire test-pyramid)
 - o Manufacturing documentation
 - o Quality documentation for the delivered system
 - o Quality substantiation documentation

Note: As the permit to fly documentation has to be endorsed by AH CVE's, a harmonization process with AH of the Permit to fly documentation has to be forecasted

This phase include the tests to be performed by the Core-partner at the level of the components (or sub-components) to contribute to permit to fly

Phase 6

This phase is dedicated to solve the manufacturing and/or assembling concerns on the system itself if they happen. The goal is to answer to dedicated non conformities (manufacturing and/or assembling problems) by discarding or managing the parts (inspection reports, concessions).

Note: All parts or assemblies under concessions that the Core-Partner(s) intend(s) to deliver to AH for demonstrator must be preliminary discussed with AH. Depending on the consequences of the part non conformities under concession, AH reserved its right to refuse it. This has to be discussed during harmonization process for permit to fly.

Phase 7

This phase is dedicated to perform test to check a satisfactory behavior of system with other aircraft components done by different partners (AH included) in order to substantiate process, to demonstrate the achieved level of safety and to get the necessary data to analyze the tests results.

The Core-Partner(s) must be strongly involved in tests (ground and flight) management of this phase by:

- Participating to test preparation meetings
- Checking and validating the different interfaces in its scope
- Participating to test request
- Participating to kit drawings
- Manufacturing kit drawings
- Participating to bench check and validation
- Supporting the test follow up if needed.

Phase 8

This phase is dedicated to define the special flight monitoring system for the drive system that will be

used on flight demonstrator.

Accelerometers, temperature probes, strain gauges and other necessary monitoring system must be defined and discussed with AH for installation.

A harmonization process with AH on special flight monitoring system has to be forecasted

Phase 9

Flight test-phases conducted by AH need the support of the Core-partner:

- To have a direct link between developer/manufacture for quick response in case of malfunctions, defects, improvements etc.
- To ensure quick feedback to the Core-Partner(s) from test campaigns
- To ensure quick improvements from Core-Partner(s), if necessary

The goal of this phase is to give solutions to assembly issues on flight demonstrator and to technical problems that can be encountered during ground/flight tests. In those cases, instructions and work approval on quality folder have to be done.

In case of incident in development, dedicated task force and methods (PPS for example) have to be put in place to solve the problem

The Core-Partner has to participate and provide input to the project synthesis, particularly, taking the lesson's learn of the demonstration evaluation and support the Technical evaluation process and the necessary estimations to define the characteristics of a commercial product.

3. Special skills, certification or equipment expected from the Applicant

Requirements needed to achieve a permit to fly:

- Providing material data which are required to achieve a permit to fly
- Using material, processes, tools, calculation tools etc. which are commonly accepted in the aeronautic industry and certification authorities.
- Harmonization (AH- Core-Partner(s)) of calculation processes/tools
- Acting interactive with AH at any state of work
- Access to the production sites
- It is expected, that TRL level 4 is achieved for each system/technology proposed in 2015 at the latest. If this is not achieved on time, Core-Partner(s) has to initiate a mitigation plan in order to reach the target of TRL 6 at the end of demonstration.
- The Core-Partner(s) has to perform updates of documentation in case of in-sufficient content for authorities.

The above mentioned requirements will be fixed in more details during the partner agreement phase. This will also include the IP-process.

Special Skills

Mandatory

The applicant(s) shall describe its experience/capacities in the following subjects:

- Experience in design and sizing of gearbox for rotorcraft.
- Tools for design and stress analysis in the aeronautical industry (i.e. CATIA v5 release 21, SAMCEF etc...)
- Capacity and experience in manufacturing parts for rotorcraft drive system (gears, housings, shafts etc...)
- Capacity to assess and eventually repair “in-shop” components due to manufacturing deviations.
- Experience in specifying equipment and following suppliers for rotorcraft drive system (bearings, free wheels, sensors etc...), housings, shafts etc...
- Capacity and experience to assemble rotorcraft gearboxes.
- Capacity and experience to test, to develop and to provide support to rotorcraft gearboxes tests
- Tests definition and preparation: stress and strain predictions, deflexion prediction and instrumentation definition
- Analysis of test results
- Capacity of evaluating the results versus the technical proposals from the beginning of the project till the end of it IAW Eco-design rules and requirements.
- Capacity of evaluating results in accordance to Horizon 2020 environmental and productivity goals following Clean Sky 2 Technology Evaluator rules and procedures.

- Competence in management of complex projects of drive system development.
- Experience with TRL Reviews in research and manufacturing projects for aeronautical industry
- Experience in integration multidisciplinary teams in concurrent engineering within reference aeronautical companies.
- Capacity of providing large aeronautical components within industrial quality standards.
- Capacity to support documentation and means of compliance to achieve prototype “Permit to Fly” with Airworthiness Authorities (i.e. EASA, FAA, national institutions and any others which apply).
- Experience in technological research and development in the following fields:
 - Gears and meshing behaviour
 - Bearings behaviour
 - Lubrication/cooling system
 - Innovative processes (welding, heat treatment, protections, coatings, dimensional controls, health non-destructive controls (MPI, X ray, tomography etc...))
 - Assembly procedures
- Capacity to specify material, protection and coatings tests along the design and manufacturing phases of aeronautical components, including:
 - Characterization of innovative materials
 - Panel type tests (compression, shear, combined loads)
 - Advanced instrumentation systems
 - Impact tests

Appreciated

- Participation in international R&T projects cooperating with industrial partners, institutions, technology centres, universities and OEMs (Original Equipment Manufacturer).
- Proven experience in collaborating with reference aeronautical companies within last decades in:
 - Research and Technology programs
 - Industrial drive system developments including flight test phase and feedback

Equipment:

Following list gives an overview of possible and well known manufacturing equipment but can be appended by Core-Partner(s) approved technologies.

- Facilities and machines for:
 - Gears cutting and grinding
 - Splines cutting and grinding
 - Housings machining
 - Heat treatment
 - Nitriding, Carburizing
 - Hard coating projection
- Non Destructive Inspection (NDI):

- MPI, FPI
- Eddy current inspection
- ultrasonic inspection
- X – ray
- Tomography
- Dimensional inspection systems
- Facilities and workshop for drive system assemblies
- Dedicated Bench test rigs (specific, functional, power etc...)

Certification:

- Design Organization Approval (DOA).
- Product Organization Approvals (POA).
- Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004)
- Qualification as Material and Ground Testing Laboratory of reference aeronautical companies (i.e. ISO 17025 and Nadcap).
- Qualification as strategic supplier of structural test on aeronautical elements.

Data management:

The leader will use the following tools for drawing and data management:

- CATIA V5 R21
- VPM compatible
- SAP compatible

The Core-Partner(s) will provide interface drawings and 3D model for digital mock-up in CATIA V5.

The data necessary for configuration management have to be provided in a format compatible with VPM tool

General requirements of the drive system**Main functions**

- Transfer and increase the torque from input to output of the module
- Transfer and reduce the speed from input to output of the module
- Withstand and transfer external loads
- Provide drive system monitoring
- Transfer a reverse torque on PGB only
- Enable Large pitch attitude operation range

Sub functions:

- Provide support and provisions for other functions:
 - Hydraulics system
 - Electrical system
 - Health monitoring system
 - Environmental conditioning System

General requirements

- Input module : input Torque : [850 to 1100N.m], Input speed: [18000 to 24000rpm], Ratio: [2.2 et 3]
- PGB: Torque output [5000 to 6500N.m], Speed [1400rpm to 2200rpm], Ratio [2 to 3.5].
- Light Weight. Objectives for PGBs and for Input Modules will be defined in specification.
- Space allocation for Clutch/declutch system between propellers and drive system capability.(see NOTE below)
- Torquemeter measurement for each Propeller gearbox.(see NOTE below)
- Operation in loss of lubricant mode for >30 minutes
- CS29 certifiable (Category A)
- Maximum efficiency (minimization of power losses)
- TBO of 5000 hours with rate reach of 80 %
- SLL objective for parts 20000 hours
- Reduced and easy maintenance
- Eco friendly materials and processes .(see NOTE below)
- Quality in accordance to a serial product

NOTE:

- Clutch/declutch function for propeller consists of managing the drive of the propellers on ground.
- Detailed clutch/declutch function for propellers is not available yet. It will be described in leader's specification.
- A Torquemeter measurement is required but up to now, the mean of measurement and the position of measurement are not defined.
- Materials & Processes :Selection of materials and manufacturing processes to be harmonized with AH

General Process for establishing weight and recurring cost breakdown

Weight:

The target is to obtain the lowest weight possible for the proposed component compliant with the technical requirements and compatible with a serial aeronautical production.

In its offer, the applicant(s) shall provide an estimated maximum weight of its proposed component. This value will be updated for the signature of the consortium agreement regarding the design data available at this time. The difference with the weight provided with the offer will be substantiated and the new weight figure will have to be agreed with the leader

For the PDR, the core-partner will have to provide a detailed weight breakdown of the component in accordance with the technology, the technical requirement and the interfaces agreed with the leader. The difference with the weight agreed in the consortium agreement will be substantiated and submitted to the approval of the leader.

For the CDR, the Core-partner will provide an update of the weight breakdown with a substantiation of the difference with the PDR version. If an update of the overall weight is necessary, it will be submitted to the approval of the leader.

The components for the flying demo will be delivered with a weight record sheet and deviations from the target agreed during CDR will be substantiated.

At the end of the demonstration phase, the core-partner will provide a weight estimation of the component for serial production in accordance with the lessons learned during the demo phase. Differences from CDR weight have to be explained.

Recurring cost estimation:

The target is to obtain the optimum between the level of performances of the fast rotorcraft and the cost of the potential product.

For the PDR, the core-partner will provide an estimation of the recurring cost of the component on the basis of the specifications given by the leader. Updates will be provided for the CDR and at the end of the demonstration phase.

4. Major deliverables and schedule

Deliverables			
Ref. No.	Title - Description	Type	Due Date
<i>FRC2.6.1-M1</i>	T0 = Project frozen (3D, first sizing for gears and bearings etc..)	Milestone	Avril 2015
<i>FRC2.6.1-D1</i>	Released interface drawings,	Drawings	T0+6 months
<i>FRC2.6.1-M2</i>	PDR	Milestone	T0+8 months
<i>FRC2.6.1-D2</i>	Released detail Studies,	Report Drawings	T0+8months
<i>FRC2.6.1-D3</i>	PDR capitalization	Report	T0+9 months
<i>FRC2.6.1-M3</i>	CDR	Milestone	T0+20 months
<i>FRC2.6.1-D4</i>	parts substantiation folders	Report	T0+20 months
<i>FRC2.6.1-D5</i>	Released drawing set	Drawings	T0+20 months
<i>FRC2.6.1-D6</i>	CDR capitalization	Report	T0+21 months
<i>FRC2.6.1-M4</i>	Development assemblies delivery for integration tests (input modules)	Milestone	T0+27 months
<i>FRC2.6.1-D7</i>	Tests capitalization	Report Drawings	T0+33 months
<i>FRC2.6.1-M5</i>	Flight Assemblies delivery for demonstrator	Milestone	T0+33 months
<i>FRC2.6.1-M6</i>	Flight Clearance	Milestone	T0+39 months
<i>FRC2.6.1-D8</i>	Flight Clearance folder (certification plan, limitations, directives, FMECA, maintenance doc etc...)	Report	T0+39 months
<i>FRC2.6.1-M7</i>	First Flight	Milestone	T0+45 months
<i>FRC2.6.1-D9</i>	Analysis of flight tests results and estimation of evolution needs for a serial product based on the demo lessons learned	Report	T0+63 months

5. Definition of terms:

- TRL : Test readiness Level
- MGB : Main GearBox
- PGB : Propeller GearBox
- WP : Work Package
- AH : Airbus
- FEM : Finite Element Model
- PDR : Preliminary design Review
- CDR: Critical design Review
- FMECA : Failure Mode Effect and Consequence Analysis
- FHA : Failure Hazard Analysis
- PPS : Practical Problem Solving
- DOA : Design Organization Agreement
- POA : Production Organization Agreement
- SLL : Safe Life Limit
- TBO : Time Between Overhaul
- RC : Recurring cost
- DMC : Direct Maintenance Cost
- CVE ; Certification Verification Engineer
- MPI : Magnetic Penetrant Inspection
- FPI: Fluorescent Penetrant Inspection

Clean Sky 2 – Airframe ITD

I. New Innovative Aircraft Configurations and Related Issues

Leader and Programme Area [SPD]	AIR		
Work Packages (to which it refers in the JTP)	A-1, A-2, A-4.2, B-1.1, B-4.1		
Indicative Topic Funding Value	16,5 M€		
Leading Company	Dassault Aviation		
Duration of the action	8 Years	Start Date	01/04/2015
Date of Issue	Draft 22/05/2014	Call Wave	1

Topic Number	Title		
JTI-CS2-2014-CPW01-AIR-01-01	New Innovative Aircraft Configurations and Related Issues	Duration	8 Years
		Start Date	01/04/2015

Short description and terms of reference:

In the High Performance and Energy Efficiency (HPE) activity line of the AIRFRAME ITD, 3 Technology Streams are directly related to the more performing overall aircraft architecture: Innovative Aircraft Architecture (TS A-1), Advanced Laminarity (TS A-2) and Novel Control (TS A-4, especially the Active Load Control A-4.2). The present topic is to endow the team with an enabler acting at aircraft architecture level by bringing multi-physic skills. The Core-Partner(s) will contribute as follow on the 3 TS:

A-1 - Contribution to engine relevant integration studies, engine concepts analysis and engine performance assessment. Participation to the aircraft manufacturer architectural works:

- Design preliminary concept and identify the main configuration parameters for MDO detail design
- Design of new structural concepts (wing and fuselage) and assessment of the weight and the aerodynamic impacts
- Detail design with high fidelity MDO approaches to identify optimal aircraft configurations accounting for aerodynamics, aeroelasticity, and structure.
- Contribution to multi-disciplinary novel powerplant integration related to both Open Rotor and Ultra High by-pass ratio turbofan engines.

A-2 - Core-Partner(s) will contribute for part design optimization & manufacturing especially at level of technologies for laminar surfaces. Applications will cover wing surfaces as well as nacelle external surfaces.

A-4.2 – The Core-Partner(s) will contribute to development of methodology and system for the load, vibration and flutter active control. It will participate to ground and in flight tests and validation and in the definition of an approach to certification

In the High Versatility and Cost Efficiency (HVE) activity line, several technical streams include the optimization of the overall aerodynamic performance through the design of specific components, especially so for compound rotorcraft.

B-1.1 (wing for incremental lift) and B-4.1 (Rotor-less tail) - The Core-Partner(s) is (are) expected to master and exploit a broad background in propeller aircraft and rotorcraft aerodynamics/aeroacoustics in order to support the compound aircraft integration in the endeavour to design a highly efficient hybrid air vehicle with low CO₂ emission and acoustic signature.

1. Background

In the High Performance and Energy Efficiency (HPE) activity line of the AIRFRAME ITD, 3 Technology Streams are directly related to the overall aircraft architectures: Innovative Aircraft Architecture (TS A-1), Advanced Laminarity (TS A-2) and Novel Control (TS A-4, especially for the Active Load Control A-4.2). All these activities are particularly linked together as having strong direct impact on the overall architecture and require a single Core-Partner (possibly represented by a consortium/cluster) to support aircraft manufacturers in the modelling, analysis and testing of physical phenomena, and elaboration at TRLs 2 to 4 of integrated control concepts for flow, noise and loads.

The related WPs are devoted to produce concepts and technologies devoted to the improvement of the aircraft performances and having a large impact on the overall aircraft architecture. The ST is consequently focused of Large Passenger Aircrafts and business jet especially requested to be more and more performing in the future. It will be driven by innovative short term configurations proposed by aircraft manufacturers as well as 2030-2050 more disruptive configurations to be proposed by the Core-Partner(s).

In order to support the aircraft manufacturers (Airbus, Dassault Aviation, SAAB) the Core-Partner(s) will have to contribute on a large range of activities requested to cope with the aircraft architecture level:

- Use of large ground test means for industrial applications (up to TRL 5) and support to flight tests,
- Analysis of test and modelling results for validation methodology purposes,
- Elaboration of design methodology on design optimisation and validation.

A cluster/consortium as Core-Partner could be necessary to cover this versatile requirement.

Innovative Aircraft Architecture

The tremendous aircraft performance increase achieved during the last decades has been made mainly thanks to successive introduction of component improvements of a conventional overall architecture which has itself barely evolved since. The ambitious FlightPath 2050 targets cannot be reached only through component optimisation. It requires changes in the aircraft architecture itself, in order to overcome current limitations like achieving very high aspect ratio, to integrate radically new equipment like Open Rotor engines, to find new smart combinations such as airframe & propulsion with the buried engine and also to maximise the individual gains on components thanks to better integration.

The aim of this Technology Stream is to demonstrate the viability of some most promising advanced aircraft concepts (identifying the key potential showstoppers & exploring relevant solutions, elaborating candidate concepts) and assessing their potentialities.

Three main work-packages will enable to explore 2 major sets of innovative aircraft architecture:

Advanced Engine Integration, with WP A-1.1 Optimal engine integration on rear fuselage to propose new airframe concept, serving both engine & airframe efficiency

Novel Overall Architectures, where step changes of the concept of one major component like the wing or the engine induce a comprehensive revisit of the aircraft architecture and of the engine integration. It is composed of 2 Work-Packages: WP A-1.2 **Open Rotor (CROR) and Ultra High by-pass ratio turbofan engine configurations** and WP A-1.3 **Novel high efficiency configurations** (with goals to emphasis important A/C performances as fuel consumption, cruise speed, passengers comfort ...etc.).

Advanced Laminarity

This Technology Stream aims to increase the **Nacelle and Wing Efficiencies** by the mean of **Extended Laminarity technologies**.

Laminarity is one of the most important technological routes toward the high efficient wing, as it can provide a significant improvement on drag & aircraft aerodynamic efficiency.

Major demonstrations of natural laminarity for a partially modified wing will be performed in Clean Sky. This demonstration will validate the concept, but is still partial as laminarity will be achieved on a limited zone of the wing (roughly ¼).

The next step is now to achieve a full integration and a global demonstration of the complete wing. A full scale Natural Laminar Flow (NLF) Smart Integrated Wing demonstrator is the core of this Technology Stream, to ensure verification & validation of the laminar wing design, as a basic contributor to the global flying demonstration in the Large Passenger Aircraft IADP.

Engine integration is also a key contributor to the overall aircraft aero-performance. Laminarity is also contemplated as a valuable path for improvement of the nacelle performances for new generation.

In the view of a larger implementation of the laminarity on other components than the wing & nacelle (tail planes, fuselage, and nacelle) and its extension toward higher speeds, technological works on Extended Laminarity will demonstrate potential and feasibility of key techniques & local systems, as a synergetic, transverse activity.

Load, Vibration and Flutter Control

Flight control systems are now very efficient thanks to all the significant improvements that have been achieved in the last decades, participating to both flight safety and aircraft flight qualities. Full digital control system, efficient actuators are now mature flying technology.

The new challenges that could bring step change gains do not more lay in the optimisation of the flight control system component performing its duty of controlling the flight, but to open the perspective to the flight control system as a system contributing to the global architecture optimization. It could contribute to sizing requirements alleviations, thanks to a smart control of the flight dynamics.

To be fully satisfactory, these enhanced A/C control strategy should maintain or increase the performance already achieved in the domain of A/C handling qualities and A/C load alleviation, which have become the current standard. A way to cope with actual or future A/C systems limitations (actuators speed limit, onboard computers capacities and architecture ...) must also be found. It is a key factor of successful application of these new technologies at A/C level.

The key objective is to reduce the global aircraft weight, either by mutualisation of functions (lift, & A/C control) in a single mobile part, reducing then the number of control surfaces, or by load alleviation with active load control. Such will lead to the reduction of consumed fuel and CO₂ footprint.

Compound Rotorcraft aerodynamics and aeroacoustics

In the High Versatility and Cost Efficiency (HVE) activity line of the AIRFRAME ITD, the work packages B1.1 and B4.1 led by Airbus Helicopters will allow designing, manufacturing and delivering for integration two key airframe components implementing advanced construction technologies. They concern respectively the wing and the tail unit.

The definition of aerodynamic surfaces for these specific airframe components which has a direct or indirect impact on the whole vehicle performance and noise emission cannot be determined in isolation but must on the contrary be considered in close connection with the general vehicle architecture and with the design of other components performed in Fast Rotorcraft IADP (work package FRC2). Indeed very complex and multiple mutual interactions occur on such a hybrid vehicle making the aerodynamic and aeroacoustic simulations a global and challenging exercise.

With wing supporting propellers to be defined, the rotorcraft integrator is faced with design activities it is not familiar with. Consequently, the support of laboratories or research institutes having in-depth experience and proven capabilities for both conventional aircraft and helicopter are required in the fields of complete vehicle aerodynamics and aeroacoustics in order to address in particular the following items:

- Wing aerodynamics integrating interactional effects;
- Tail unit aerodynamics for stability and control;
- Propeller aerodynamics and aeroacoustics integrating interactional effects;
- Noise shielding effect of the wing and fuselage.

2. Scope of work

At aircraft architecture level the Core-Partner(s) will support the airframe manufacturers for the integration to the OAD of technologies and concepts to developed and validated on the 3 concerned TS.

2.1 - Innovative Aircraft Architecture (TS A-1)

2.1.1 - Optimal Engine Integration on Rear Fuselage (link to WP A-1.1)

The global objective is to look at significant gain to the aircraft performances (fuel consumption, flight domain, flight handling qualities, noise footprint, etc.) thanks to advanced engine integration with the rear fuselage, main technical topics to address are:

- Buried engines (aft body drag reduction and noise shielding)
- Boundary layer ingestion (fuselage drag reduction)
- High BPR engine (high SFC)
- Noise reduction (passive and/or active system)
- Vectored thrust (Enhanced flight qualities and/or better performances through trim drag reduction)
- Distributed thrust (aerothermodynamics cycle efficiency optimization, more electrical A/C)

Main activities (which can be declined for each technologic topic) required from the Core-Partner(s) are as follows:

- Definition and preliminary design of innovative rear fuselage concepts with a A/C level design constraint (ground clearance, certification requirement ...etc)
- Studies of aircraft configurations with varying engine position to assess engine-airframe coupling : evaluation of the disturbance flow with final objective to estimate the impact on the engine inlet/fan performance
- With an engine manufacturer, study of inlet distortion impact on the engine performances (thrust, SFC and life cycle) and assessment of the maximum disturbance allowing by the engine
- Detail design of rear-fuselage engine integration, location of the main A/C structure parts, external shape CAD
- Assessment of the rear fuselage characteristics: aerodynamic (local and overall A/C), noise shielding, weight, inlet flow distortion and A/C system impact (electrics system, hydraulics system ...etc)
- Assessment of advanced rear fuselage impact on A/C performances (range, BFL, LFL, noise emission, fuel emission ...etc.) in accordance with an OAD process (A/C level)
- WTT to validate distortion evaluation

2.1.2 - Open Rotor (CROR) and Ultra High by-pass ratio turbofan engine configurations (link to WP A-1.2)

2.1.2.1 - Aerodynamics

Objectives:

- Understanding of CROR physics and integration on A/C and development of associated capabilities to support CROR viability demonstration
- Understanding of fan/airframe aerodynamic integration and development of associated capabilities
- Some of the solutions and capabilities developed in this frame will be tested / validated through experiments and Flight tests (in Clean Sky LPA platform)

Topics:

- Blade deformation computation, evaluation (performance, 1P loads, whirl flutter, aero-acoustics, vibrations...) and WTT comparison for several designs and scales.
- Transition prediction : CFD development, blade laminarity diagnosis
- Accuracy improvement of 1P loads and moments prediction from various methods (such as actuator disk, unsteady computations) and WTT calibration.
- Assess propeller robustness to inflow disturbances
- Steady and Unsteady assessment of innovative CROR rear fuselage (pre/post test)
- Predictive CFD on several blade design to get design sensitivity and validation through WTT
- CROR forced movement with complete A/C for whirl flutter purpose
- Development of far-field drag post-processing for unsteady computations
- CROR in reverse thrust and off-design numerical evaluation (simplified /advanced methods).
- Turbofan nacelle in reverse thrust numerical evaluation on full A/C configurations
- Unsteady CFD capability for air intake in crosswind with ground
- CFD to qualify A/C system integration within powerplant to minimize impact on engine
- Active and passive flow control solutions / capabilities / validation for close coupled powerplant under-wing integration.
- Skin friction prediction on smooth and porous cold and hot surfaces, low friction solutions.
- Replace semi-empirical by high-fidelity “parasitic drag” (steps, gaps, leakages) methods.
- Move towards an energy-based design of the overall A/C: applications to aerodynamics (and especially air systems inlets/outlets and BLI engines) but also to systems themselves, energy harvesting...
- Characterisation of CROR vibration source on CROR Aircraft (inflow impact, incl ground).
- Characterize the slipstream effect on rear end: HTP and VTP buffeting
- Characterisation of the flutter A/C and whirl flutter (propeller effect)

2.1.2.2 - Acoustics

CROR and TF Challenges and technologies

TF: The applicant(s) is (are) expected to bring significant contributions in the characterization, the understanding and potentially low noise solutions with regards to the following noise challenges

- Shorter inlet and bypass duct: reduction of treated area + Inlet flow distortion noise
- GTF Engine: Lower regime but shift of the global spectrum to lower frequencies, more difficult to attenuate with classical liners. Possible BSN in cruise. Mitigation : Innovative liners (metamaterials, hybrid...) for low freq/broader attenuation
- Reduction of Fan-OGV space, low count OGV.
- Increased close-coupling between engine and wing during takeoff and approach leading to jet-wing interaction noise. New architectures of bypass nozzle and pylons
- Acoustics treatments characterisation with grazing flow and thermal gradient

CROR: Study of alternative configuration proposed by Airbus in order to demonstrate economic viability and reduction of uncertainties in FFN, NFN and En route Noise predictions vs limitations.

CFD-CAA

Numerical methods for CROR only

- Study of alternative configuration (sense of rotation, new engine position, pitch control). Effect of blade deformation on acoustics. Analysis/understanding of interaction tones mechanisms.

Numerical methods for TF only

- Heterogeneous OGV and pylon/bifurcations/splitters impact on Fan-OGV interactions,
- Non linear propagation of shocks (BSN) with heterogeneous 3D geometry/flow and acoustics treatments. Acoustics treatment modelling in time-domain propagation

Numerical methods for CROR and TF

- Tones : Validation of numerical methods over available low & high speed tests (performed in CS1 (CROR) & to be done CS2 (CROR/TF))
- Broadband noise modelling using SNGR/RPM like methods
- DES/LES simulation for tonal & broadband noise for single rotor and CROR/TF
- High order CFD/CAA coupling for noise propagation in non uniform inflow. Impact of using NLDE instead of FWH for acoustic propagation
- Tool validation wrt fuselage turbulent boundary layer refraction effects
- Fan noise scaling laws method (PROPNOISE) following POWER25 project
- Multi Disciplinary Optimization (MDO) tool development for CROR and UHBR acoustics, performance based on elsA. Adjoint equations of FWH
- Lattice boltzman simulation for tonal & broadband noise (LABS code) (CROR/TF)
- Evaluation of multichorochronic CFD approach for acoustics

- Impact of (computed) transition on acoustics and detailed geometry (gaps, holes)

Experimental characterisation

High speed and low speed CROR/TF wind tunnel tests

- Contribution to CROR WTT definitions (num simulation, WT hardware definition)
- Contribution to Large size TF rig definition and instrumentation. Need of modularity (liners, technologies), incidence effects with distortion and installation effects (close coupling with wing)

Inflow Instrumentation for WTT

- Metrology development for in-flow acoustic instrumentation for WTT and for FTD (to be followed in LPA platform) Contribution to instrumentation WTT definitions
- Instrumentation development WT test LS (2 test entries) and HS (2 test entries)
- Specific Instrumentation for TF : modal detection, hot wire, LDV, wall kulites close to blades and OGVs,
- PIV (static /dynamic) and time-resolved turbulence measurements (e.g. LDV) for installed jet noise characterization

Acoustic WTT post processing with corrections

- Screen recessed microphone development and correction (wire mesh...), Penny washer correction
- Near field : TBL (steady and unsteady) refraction correction, WTT Acoustic liner development for HS tests
- Far field : Open test section shear layer refraction correction
- Denoising (non acoustic source noise, TBL noise), Dereverberation in WTT, method development and validation

2.1.2.3 Experimental development

It is anticipated that for the test methodology there will be significant commonality between the instrumentation, data acquisition systems, advanced measurement techniques (specifically acoustic) and test technologies that are developed for both low and high speed applications. The Wind-tunnel tests will be performed in the frame of CFT.

Advanced measurement techniques	CROR Specific Topics	UHBR Specific Topics
<u>Wind Tunnel Infrastructure</u> - Investigate adjustment of air supply capacity & max mass flow rates in all WTT facilities to anticipate needs related to powered models & rigs for CROR and large By-Pass ratio Turbofan Engines. - Air supply capacity & max mass flow rates in all WTT facilities - High Speed Acoustic Liner - Update of dynamic calibration facilities <u>Test Methodologies</u> - RSB Design & Manufacturing with associated calibrations (static and dynamic) - Main balance and uncoupling system D&M + calibration - New technology of local balances for influence model or nacelle D&M and calibration - Telemetry D&M + data acquisition system, post processing in the required data format - Nozzle (Reference model) development (design & manufacture) - Global measurement accuracy improvement - Advanced measurement technologies development / industrialization to include: - PIV (static /dynamic) and time-resolved turbulence measurements (e.g. LDV) for installed jet noise characterization - PSP /TSP (static /dynamic) - IR Transition detection - Blade deformation (static / dynamic) - Acoustic test methodology & hardware development for NFN, FFN & model components (including rotating components) - Advanced instrumentation toward Fan/OGV aero-acoustic characterization in isolated and installed configuration (modal detection, hot wire LDV?, kulites close to blades and OGVs, Near field measurements, mic array, anechoicity...) - Global measurements accuracy improvement	<u>Blade 2D test (large scale blade profile in high speed wind tunnel (0.2 to 0.7))</u> - Core partner Wind Tunnel Test including all activities related to the test preparation, model commissioning, wind tunnel shakedown and de-rigging - Specific Test Equipment High Fidelity Aerodynamic test measurement & methodology development <u>1/10th isolated CROR Wind Tunnel Test in high speed large WT Sept. 2015</u> - Core partner Wind Tunnel Test including all activities related to the test preparation, model commissioning, wind tunnel shakedown and de-rigging - Core Partner Model Hardware / all model mounting hardware, telemetry systems RSB's & Software - Specific Test Equipment High Fidelity Acoustic test measurement & methodology development	<u>UHBR Large Fan Rig Q2 2017 in Propulsor Rig A/C Performance</u> - Core partner Wind Tunnel Test including all activities related to the test preparation, model commissioning, wind tunnel shakedown and de-rigging - Specific Test Equipment High Fidelity Acoustic test measurement & methodology development <u>UHBR Large Fan Rig Q4 2017 in large low speed WT Aircraft Performance</u> - Core Partner Model Hardware / all model mounting hardware, Strain Gauge Balance telemetry systems RSB's & Software <u>UHBR Large Fan Rig Q4 2017 in large open section low speed WT Acoustic</u> - Core Partner Model Hardware / all model mounting hardware, Strain Gauge Balance telemetry systems RSB's & Software <u>UHBR Large Fan Rig Q2 2018 in high speed large WT Aircraft Performance</u> - Core partner Wind Tunnel Test including all activities related to the test preparation, model commissioning, wind tunnel shakedown and de-rigging - Core Partner Model Hardware / all model mounting hardware, Strain Gauge Balance telemetry systems RSB's & Software - Specific Test Equipment High Fidelity test measurement & methodology development and flow visualization <u>UHBR Large Fan Rig Q2 2018 in high speed large WT Acoustic</u> - Core partner Wind Tunnel Test including all activities related to the test preparation, model commissioning, wind tunnel shakedown and de-rigging - Core Partner Model Hardware / all model mounting hardware, Strain Gauge Balance telemetry systems RSB's & Software - Specific Test Equipment High Fidelity Acoustic test measurement & methodology development & Design, manufacture, installation and commission of an Acoustic Tunnel liner

2.1.2.4 CROR powerplant, Rear End and physical integration

Blade modeling and Design

- The blade design is key to fulfill 2 main technology drivers: the tolerance to impact on blade and the reduction of weight of the powerplant. As such, the following activities would be required: Investigation of lightweight material and concept for the blade, capability for high velocity impact and residual strength analysis on blade, and analysis of flutter for the blade
- Icing studies for CROR certification:** Modelling of ice accretion on blades (collection efficiency, ice shapes), Application to ice shape predictions on CROR, Ice shedding, ice block trajectory & ice block impact modelling, Ice block impact from airframe on CROR engine.
- Ventilation & drainage for CROR:** Alternative solutions for drainage to mitigate safety risks of classical drainage architecture), Methodology to characterize the passage of drained liquid through the contra rotating stage of the engine, Ventilation principles to cool engine fixed module, Alternative ventilation principles to cool engine rotating module, Methodology to characterize the blade aero-thermal environment due the impingement with hot airflow.

CROR Blade off release and Impact

- CROR Blade Debris impact analysis: High Fidelity simulations for composite blade impact on composite fuselage, capability for simulations of blade debris rebound on fuselage panel, determination of debris post impact, Composite-composite impact characterization low and middle level, Support in the definition of light weight shielding against rear mounted Engines threats.. Blade impact failure mechanism and energy absorption mechanisms identification and evaluation.

Engine vibrations and blade off dynamics loads

- Engine Dynamic loads and blade off Imbalance loads prediction, dynamic and vibration analysis. Support on the definition of alternative vibration free engine attachment interface.
- Prediction of engine mounts forces in case of blade/debris release or ice/bird impacts. Low level test and simulation for application on engine mounted Rear End structure.

2.1.2.5 Acoustic efficient fuselage & technologies

Key for the development of highly (structural) integrated and multi-functional noise control measures and acoustics concepts is the structure-dynamical characterization of large fuselages. Today, vibration sensors with cabelling do require a huge test effort as well as test equipment.

A method for contact-less measurement of structure-dynamic behaviors of large structures (>2000 measurement points) is proposed. An automation of the test procedure/conduction is highly desired.

2.1.3 - Novel High Efficiency Configurations ([link to WP A-1.3](#))

The global objective is to look at significant gain to the aircraft performances (fuel consumption, flight domain, flight handling qualities, noise footprint, etc.) by introducing radically new concepts in the overall architecture such as none cylindrical fuselage, very large fuselage or rhomboidal wing. Studies must adapt the A/C specifications (Range, Mach and cabin size) to optimize the A/C efficiency.

Main technical topics are:

- Innovative wing (to perform a high lift-to-drag ratio for a reduced wing weight, such as rhomboidal or strutted wing)
- Non-cylindrical fuselage (area ruling to improve high Mach efficiency, or higher volume with same wetted area to improve comfort)
- Flying wing configuration (to reach high lift-to-drag ratio, to allow larger cabin, to integrate innovative propulsion concepts)
- Others propositions from Core-Partner(s)

Main activities required from the Core-Partner(s) are here after described; they must address each of the previous topics:

- Design preliminary innovative concepts and identify the main configuration parameters for MDO detail design. Some parameters could have a deep impact on performance, such as the attachment location between upper and lower wing for the rhomboidal/strutted wing or the engine location. The concepts must be compliant with high level A/C design constraints (to reach manufacturing feasibility, exploitation constraints and certification requirements)

- Design of new structural concepts (wing and fuselage), assessment of weights and aerodynamic impacts (with the goal to provide an aerodynamic and structural models for MDO)
- MDO to identify optimal aircraft configurations accounting for aerodynamics, aero elasticity, and structures. Considering optimisation, the figure of merit will be: noise (noise sources and shielding potential should be taken into account), fuel consumption, NO_x emissions, cruise speed and passenger comfort. Pareto efficient frontier will be used to analyse the results
- WTT to validate aerodynamic benefit expecting from innovative architectures, and provide data for Handling Qualities assessment

2.2 –Advanced Laminar Flow (TS A-2)

2.2.1 - Laminar Nacelle (link to WP A-2.1)

With most advanced, most fuel efficient next generation turbofan engines growing even bigger in diameter, weight and friction drag penalties are the key parameters to determine the equilibrium between net benefit or net penalty when integrated and operated at aircraft level. Improvements in the nacelle global aerodynamic qualities are then required, and laminarity is a technology route with a good potential of achievement.

The key technical objective is of fully multidisciplinary nature: combine a low weight structure that enable high surface quality and low tolerances in waviness, steps and gaps, while ensuring appropriate integration and access to all relevant aircraft and engine systems. R&T of the manufacturing and assembling strategy and methods is a key element of the work package

The laminarity extension cord objective is 25 % with NLF and 35 % with HLFC on both lateral and central nacelles for a three-engine aircraft. The qualities of the nacelle won't be changed in cross wind conditions and at low speed.

The objectives in term of TRL are:

- For NLF: TRL5 at the end of 2016 and TRL6 at the of 2018
- for HLFC: TRL5 mid 2018 and TRL6 at the end of 2019

Main activities required from the Core-Partner(s) are as follows:

- Robust aerodynamic re-design of the nacelle shape taking account the interactions with the fuselage
- Determination of tolerable geometrical disturbances using a prediction-correction cycle with structural design and manufacture consequences
- Structural concept development to enable laminar flow to survive local disturbances at access doors
- Design of NACA and hot air exhaust
- Clear assessment of benefits and operational limitations of NLF nacelle

- HLFC suction system design, integration, assessment including system simulations, added weight, energy consumption, feasibility, safety and reliability
- Assessment of NLF nacelle vs. HLFC nacelle on OAD level
- Extension of existing transition criteria with suction
- Demonstration of integration compliance with major systems components and hot air ice protection system in particular
- Contributions to large scale demonstrators:
 - Instrumentation and optic means to show the extension of the laminarity on the modified nacelles during flight tests
 - Dedicated structural component tests (full size)

2.2.2 - NFL (Natural Laminar Flow) smart integrated wing (link to WP A-2.2)

The current view is that the NLF wing has the firm potential to reduce the drag during cruise by 6-7% at aircraft level compared to the latest state-of-the-art turbulent wing. Giving the facts of more stringent surface quality requirements and a number of other constraints compared to the conventional design, the significant fuel burn potential of the NLF concept can only be turned into a strong contribution to industrial leadership if the drag benefit can be accomplished at similar or lower weight and comparable or lower efforts in production and MRO.

The key target is to develop and demonstrate an integrated wing concept that demonstrates this capability of the concept or even beyond.

The “Large scale NLF smart wing integrated demonstrator” will demonstrate the synthesis of the results from SFWA and other programmes so that such a concept can be manufactured, produced and maintained in an industrial environment, which is the explicit objective of this demonstrator.

The objectives in term of TRL are:

- TRL5 at the end of 2016
- TRL6 at the end of 2018

Main activities required from the Core-Partner(s) are as follows:

- Development and application of a new aero-structure coupled design process that leads to more robust laminar boundary layer flow in presence of surface irregularities
- Development of new concepts for weight reduced NLF wing parts with increased allowable, reduced production costs
- Studies and design for the manufacturing of ground based demonstrators, part of a full scale wing with representative structure and including control surfaces with mechanisms.
- Study of interaction shock / laminar boundary layer “strong coupling”, including the development of related modelling prediction tools.

All the wind tunnel tests and the manufacturing model parts will be under separated CfP or CfT.

2.2.3 - Extended laminarity (link to WP A-2.3)

The objective is to address aerodynamic laminar designs and innovative wing devices to obtain a leveraging level of laminarity in the vicinity of perturbed wing zones including max lift

devices (required by the take-off and landing requirements), and compatible with the structural design and manufacturing. The solutions will be evaluated in terms of aerodynamic performances and robustness of the aerodynamic solution.

Big challenge to overcome goes from the requirements for manufacturing to the severe constraints induced by the aerodynamics configuration in terms of maximum lift with the presence of leading edge devices like the slat.

Main activities required from the Core-Partner(s) are as follows:

- Determination of surface requirements for NLF at cruise
- Aerodynamic Optimization and System design for droop nose, spoiler droop, slat, Krüger device, etc...
- Kinematics design for droop systems and flap movement
- Verification of structural and system conformity to NLF
- Definition of appropriate structural concept including cost efficient manufacturing technologies
- Develop adapted design tools (modelling) for laminar wing & HTP, for profiles and suction systems
- Advanced CFDs and accurate transition modelling
- Extension of existing transition criteria with introduction of suction for HLFC
- Studies of relaminarization downstream of turbulent fuselage nose by passive and active methods
- Elaboration of the shape for a laminar front fuselage in close relation with to WP A-3.2 (Tailored Front Fuselage). The result of the activity corresponding to an input to the WP
- Perform lab tests to validate studies/CFD
- Contribution to the definition of ground based demonstrator or wind tunnel tests

2.3 – Novel Control (TS A-4)

2.3.1 - Active Load Control ([link to WP A-4.2](#))

The WP objective is to reduce the structural weight by using smartly the flight control system, in order to:

- Alleviate gust load: the aircraft structure sustains a surge of load when facing a gust, making it a sizing case for the structure. An adapted control of the aircraft to smartly fly into a gust will counter-act the gust effects, leading to the load alleviation. Once mature (i.e. validated from functional & safety points of view), this technology will enable to decrease the sizing loads envelope, leading to a significant weight reduction.
- Counter-act flutter initiation or vibrations: the smart motion of control surfaces can allow controlling vibration propagation in the A/C & damping the flutter initiation. When mature (i.e. demonstration of the simultaneous ability of the flight control system to damp & to control the flight) this technology will allow reducing the structural sizing required to meet flutter constraints, leading to a significant weight reduction.

Activity to be carried out by the Core-Partner(s) is as follows:

- Requirements
- Modelling: bridging high-fidelity to low-fidelity
- Architecture and detailed functional design (reference configuration and on alternative configurations) for loads control, flutter suppression, ...
- Address failure cases, functional monitoring, redundancy concepts
- Extensive design analysis (simulations)
- Analysis and quantification of benefits
- Address certification aspects
- Demonstration (Depending on interest of industrial partners and budget)
- Short term: 2014-2017 demonstration: Full-flight simulator
- Extended demonstration batch (2016-2022) demonstration: Reduced scale flying test bench, Flight test

2.4 – Wing for incremental lift and transmission shaft integration (TS B-1.1)

The compound rotorcraft demonstrator (LifeRCraft) to be assembled and tested in the Fast Rotorcraft IADP integrates a wing designed and manufactured in the Airframe ITD WP B4.1.

2.4.1 Wing surface design integrating interactional effects

This compound rotorcraft introduces a major novelty by integrating a wing, with the double function firstly to contribute to the rotorcraft lift and secondly, to integrate a propulsion system with a shaft to transfer power from the engine to the propellers hosted on the wing. The wing specifications deviate very significantly from the ones usual for conventional propeller aircraft since it is operating at a relatively low altitude providing only a fraction of the total rotorcraft lift and working in non symmetrical conditions. The wing is not required to provide any lift at low speed. The flap has a dual role, firstly to minimise the area exposed to the main rotor downwash in order to offer minimal interference and secondly, to adjust the wing lift in forward flight so as to control the lift distribution between the wing and main rotor for optimal performance.

Due to its position and functions, the wing is part of a complex aerodynamic interactional pattern between the main rotor, the fuselage, the propellers and nacelles located at the wing tips. This air flow pattern drastically changes depending on the detailed vehicle architecture and flight conditions, especially flight speed.

The WP objective is to tailor the geometry of wing: airfoils and flap, twist distribution, and 3D junctions with fuselage and propeller nacelles so as to reach the best possible compromise over the full flight envelope. In this way, the wing design should contribute to achieving the overall rotorcraft performance objectives concerning rotorcraft Lift-over-Drag ratio, hovering efficiency and weight reduction.

The rotorcraft integrator will specify the required aerodynamic forces and moments and the dimensional constraints along with a preliminary sizing of the wing. The Core-Partner(s) will propose an improved aerodynamic design (airfoil selection/customization, flap geometry, twist, 3D junctions with fuselage and propeller nacelles) responding to the above mentioned objectives and fulfilling the constraints.

2.4.2 Propeller surface design integrating interactional effects

The compound rotorcraft propellers have to perform two functions: firstly, to provide yaw control and anti-torque balancing the lifting rotor torque in hover and low speed conditions and secondly, to provide the largest part of propulsive force in high speed flight. Both functions have to be fulfilled with maximum efficiency i.e. with the lowest possible power consumption. The design optimized for each these functions considered individually is quite different and therefore required a careful trade-off.

The propellers are part of a complex aerodynamic interactional pattern between the main rotor, the fuselage, the propellers and nacelles. This air flow pattern drastically changes depending on the detailed vehicle architecture and on flight conditions and it strongly affects the whole vehicle performance through wing aerodynamics and propeller efficiency. It may also deeply affect propeller noise which is a serious concern both for the impact on ground and on the passengers' and crew's comfort in the cabin.

The WP objective is consequently to adapt and optimize the propeller design conducted in the Fast Rotorcraft IADP WP2.5.2 by integrating in this design process the interactions between the airframe and propellers.

The rotorcraft integrator will specify the required propeller thrust and torque in several critical points of the flight envelope, along with a preliminary design of the propeller blade surfaces and geometrical constraints. The Core-Partner(s) will propose an improved aerodynamic design (airfoil selection/customization, planform and twist distribution) for the right and left side propellers (not necessarily symmetrical) which responds to the above mentioned objectives and fulfils the constraints.

2.4.3 Noise shielding effect of the wing and fuselage

The Technology Evaluator requires among other modelling elements the provision of noise models for the whole vehicle. The main rotor and the propellers are expected to be the dominant noise sources but the wing surface partially obtruding the noise path to the ground will significantly alter the propagation hence the noise perceived on ground.

The WP objective is consequently for the Core-Partner(s) to establish a conceptual noise model in the form of hemispheres that integrates the masking effect of the airframe (wing and central fuselage) in the conditions corresponding to low altitude flight (essentially take-off and landing) as suited for Technology Evaluator needs. The methodology and tools for assessing airframe masking effects should be simple enough to be useful in a fast feedback loop during configuration selection and preliminary sizing phase of any compound rotorcraft.

2.4.4 Validation of aeroacoustic models

After completion of work package 2.4.3, the Core-Partner(s) will perform an aeroacoustic prediction exercise for a full compound rotorcraft comparing two variants of the configuration and clarifying their respective merits and shortcomings in terms of noise footprints.

In addition to feeding further releases of the TE conceptual model (for acoustics), the Core-Partner(s) is (are) expected to deliver to industry some recommendations for the selection of

the suitable configuration variant for the development of future compound rotorcraft products.

2.5 – Rotor-less Tail for Fast Rotorcraft (TS B-4.1)

The compound rotorcraft demonstrator (LifeRCraft) to be assembled and tested in the Fast Rotorcraft IADP integrates the tail unit designed and manufactured in the Airframe ITD WP B4.1.

2.5.1 Tail unit aerodynamic design

The WP objective is to tailor the geometry of tail boom and tail surfaces, both fixed surfaces and control surfaces that will allow the full vehicle to reach the desired behavior in yaw and pitch:

- in static trimmed conditions,
- in terms of dynamic stability and pilotability,

across the full flight envelope including hover and low speed, and for the whole mass and CG domain. The Flight Control System under normal operation or degraded modes has to accommodate the vehicle stability provided by the tail geometry and ensure flightworthiness according to criteria applicable to Instrument Flight Rules.

Further, the tail design should contribute to achieving the overall rotorcraft performance objectives concerning drag and weight reduction, by minimizing the size of tail surfaces.

The rotorcraft integrator will issue a preliminary design of all tail unit surfaces with possibly some variants and specify the objectives and all constraints (including dimensional constraints) of the aerodynamic study. The Core-Partner(s) will propose aerodynamic design changes such as tail boom section, airfoils for vertical and horizontal fixed and movable surfaces, 3D junctions, etc., responding to the above mentioned objectives and fulfilling the constraints

3. Special skills, capabilities – (See list under Paragraph II)

The capability of the Core-Partner(s) shall be on a large range of areas as it is required to act at aircraft level. It means a multi-disciplinary set of skills among which we have:

- Flow simulation and analysis including capability to develop new methodologies,
- A/C configuration design, sizing and optimisation
- Aero-structure design (loads & flutter evaluation) and modelling
- Acoustic, fuel consumption and NO_x emission analysis and assessments
- A/C MDO
- Excellent track of record concerning modelisation of specific rotorcraft flight physics, esp. aerodynamics and aeroacoustics
- Skills in development & validation of a methodology to design more robust engine burst containment solutions (at A/C level)
- Development and demonstration of active noise reduction systems
- WTT specifications and result analysis including modelling correlations
- Handling Qualities
- Abilities to organise and perform distortion measurement in WTT
- Development of methodology and system for the load, vibration and flutter active control, ground test and in flight tests and validation.
- Definition of approach to certification.
- Aerodynamics
 - Aerodynamic CFD modelling skills using hybrid approach, from simplified to unsteady methods
 - Aeroelasticity skills (fluid-structure coupling approach integrated force/displacement/mesh deformation approaches) and adapted to CROR blades specificities: rotation, high twist, limited aspect ratio
 - Laminar flow technology
 - Flow control simulations
- Numerical methods for CROR and TF
 - Access to TAU, KIM, PIANO codes for development and use
 - Access to elsA and KIM for use and development
- CROR powerplant related skills:
 - Low weight structure design and material
 - High velocity impact analysis
 - Flutter analysis for rotating parts
 - Post impact trajectory, residual velocity and energy analysis.
- Acoustic efficient fuselage & technologies
 - Extensive experience and capabilities on multi-channel structure-dynamical and vibro-acoustics testing of large / full scale aircraft fuselage structures (>400 channels, >2500 test positions) with multi-source excitation (parallel), data reduction, checking, problem

resolving

- Experimental development: The applicant(s) shall use the following equipments:
 - Access to B2A bench
 - Access to Cepra 19, F2 et S1 wind tunnel facilities
- CROR powerplant
 - Simulations skills & means for rotating blade debris trajectories
 - Simulations skills & means of thermal environment in fixed and rotative assemblies
 - Simulations skills & means of liquid leakage path and effect on propeller stage.
- CROR rear end topics
 - World-class experience in high energy impact simulation and test. Extensive experience in characterisation High speed deformation mechanical behaviour of innovative materials. Demonstrated knowledge and background on shielding developments.
 - World-class experience in simulation and test on blade and aero surfaces ice shedding generation, release and trajectory evaluation.
 - World-class experience in dynamic analysis, simulation and test of engine vibration and imbalance loads after blade and other debris release and other high speed dynamic phenomena.

4. Major deliverables and schedule (estimate)

<i>Deliverables</i>			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
AIR/ST1/A-1.1/1	Innovative rear fuselage concepts Paper with descriptions of different concepts of innovative rear fuselage (Loop 1 (L1) and Loop 2 (L2))	Review of preliminary concepts	09/2015 (L1) 12/2017 (L2)
AIR/ST1/A-1.1/2	Assessment of the selected concepts This paper is a synthesis of the structural, aero dynamical, acoustic and weight studies	Synthesis	12/2016 12/2019
AIR/ST1/A-1.1/3	Distortion model Distortion impact model on the engine performances (thrust, SFC and life cycle) and assessment of the maximum flow distortion allowing by the engine (engine distortion response and engine distortion tolerance)	Model	12/2016
AIR/ST1/A-1.1/4	Innovative rear fuselage analysis This study have goal to highlight Pro and Cons for each concept (with figures from AIR/ST1/A-1.1/4 and expert's considerations) with OAD assessment	Analysis	12/2016
AIR/ST1/A-1.1/5	WTT data Data from WTT. Data must allow to evaluate the impact of the rear fuselage on the inlet distortion (and consolidate cfd computation)	Data	TBD
AIR/ST1/A-1.2/1	Core-Partner(s) contribution detailed description (content, deliverables , planning)	Report	10/2015
AIR/ST1/A-1.2/2	Contribution to CROR economic viability demonstration	Report, Data	05/2017
AIR/ST1/A-1.2/3	Inputs to CROR large scale demonstration	Report, Data	01/2018
AIR/ST1/A-1.2/4	Contribution to advanced Turbofan integration: input to large scale demonstration activities	Report, Data	10/2016
AIR/ST1/A-1.2/5	Input to large Turbofan in flight demonstration	Report, Data	10/2017
AIR/ST1/A-1.2/6	Method for contact-less measurement of structure-dynamic behaviours of large or full scale fuselage structure	Method, Report, Data Process	12/2020

Deliverables			
Ref. No.	Title - Description	Type	Due Date
AIR/ST1/A-1.3/1	Innovative configuration concepts Descriptions and preliminary design of different A/C concepts. Topics for high efficiency A/C are : Emission efficiency Mach efficiency	Review of preliminary concepts	09/2015 12/2017
AIR/ST1/A-1.3/2	Structural assessment of innovative configuration concepts Weight prediction for innovative configuration concept performances assessment	Models	12/2016 12/2019
AIR/ST1/A-1.3/3	Aerodynamic assessment of innovative configuration concepts Models for drag and lift prediction for innovative configuration concept performances assessment	Models	12/2016 12/2019
AIR/ST1/A-1.3/4	High efficiency configuration definitions MDO results and analysis for innovative A/C configuration from the AIR/ST1/A-1.3/1.	Synthesis / Analysis	12/2016 12/2019
AIR/ST1/A-1.3/5	WTT data Data from WTT. Data must allow to check the aero dynamical efficiency of the innovative configuration	Data	TBD
AIR/ST1/A-2.1/1	NLF & HLFC nacelle concept (extended)	Report, Data	12/15 (NLF) 12/16 (Ext.)
AIR/ST1/A-2.1/2	Structural concept for access door integration into laminar region	Report, Data	06/16 12/18 (Ext.)
AIR/ST1/A-2.1/3	Laminar Nacelle demonstrator	Hardware	12/16 12/19 (Ext.)
AIR/ST1/A-2.2/1	Aero-structure design process chain	Process	12/16
AIR/ST1/A-2.2/2	Production and assembly technology for CFRP based NLF wing	Data, Process	12/16
AIR/ST1/A-2.2/3	Ground based demonstrator of structural concept	Hardware	12/15 12/17 (Ext.)
AIR/ST1/A-2.3/1	HLFC nose without suction chambers including other systems and functionalities like bird strike and erosion protection as well as WIPS	Report, Data	12/19
AIR/ST1/A-2.3/2	Ground based demonstrators of function integrated nose concepts	Hardware	12/19

Deliverables			
Ref. No.	Title - Description	Type	Due Date
AIR/ST1/A-2.3/3	Wind Tunnel Test of chamberless HLFC-system on existing large scale VTP wind tunnel model	Data	12/20
AIR/ST1/A-4.2/1	Loads / flutter control process within overall A/C design	Data, Process	06/18
AIR/ST1/A-4.2/2	Demonstrated control law functions: simulation	Model	12/17
AIR/ST1/A-4.2/3	Demonstrated control law functions: flight test	Data	09/22
AIR/ST1/A-4.2/4	Reports on quantitative benefits	Report, Data	12/22
AIR/ST1/B-1.1/1	Compound rotorcraft wing – Preliminary specifications of airfoils and flap, wing twist, and 3D junctions with fuselage and propeller nacelles	Report and CFD models	12/2015
AIR/ST1/B-1.1/2	Compound rotorcraft wing – Recommended geometry of airfoils and flap, wing twist, and 3D junctions with fuselage and propeller nacelles	Report and CFD models	11/2016
AIR/ST1/B-1.1/3	Compound rotorcraft wing – Anticipated impact of wing/ rotor/propeller mutual interactions on propeller surface design	Report and CFD models	12/2015
AIR/ST1/B-1.1/4	Compound rotorcraft wing – Recommended propeller surface design with impact of wing/ rotor/propeller mutual interactions	Report and CFD models	7/2016
AIR/ST1/B-1.1/5	Compound rotorcraft contribution to TE – Simplified aeroacoustic model with and without the effect of the wing and fuselage on propagation of the main rotor and propeller noise (simplified functional model)	Report and noise hemispheres	10/2015
AIR/ST1/B-1.1/6	Compound rotorcraft contribution to TE – Revised and extended aeroacoustic model with and without the effect of the wing and fuselage on propagation of the main rotor and propeller noise	Report and noise hemispheres	12/2016
AIR/ST1/B-1.1/7	Compound rotorcraft – Comparison of configuration variants concerning their acoustic emission and recommendations.	Final Report	3/2020
AIR/ST1/B-4.1/1	Compound rotorcraft tail unit – Preliminary proposition of surface design changes for tail boom and tail surfaces	Report and CFD models	12/2015

<i>Deliverables</i>			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
AIR/ST1/B-4.1/2	Compound rotorcraft tail unit – Final recommended surface design changes for tail boom and tail surfaces	Report and CFD models	11/2016

5. Definition of terms

A/C	AirCRAFT
AIR	AIRFRAME ITD
BFL	Balanced Field Length
BLI	Boundary Layer Ingestion
BPR	By Pass Ratio
BSN	Buzz Saw Noise
CAD	Computer Aided Design
CFD	Computational Fluid Dynamics
CFD-CAA	Computational Fluid Dynamics – Computational Aeroacoustics
CP	Core-Partner(s)
CROR	Contra Rotative Open Rotor
CS1	Clean Sky 1
CS2	Clean Sky 2
DES	Detached Eddy Simulation
FTD	Flight Test Device
FWH	Fowcs Williams-Hawkings acoustic analogy
GTF	Geared Turbo Fan
HLFC	Hybrid Laminar Flow Control
HPE	High Performance and Energy Efficiency
HTP	Horizontal Tail Plane
IADP	Innovative Aircraft Demonstrator Platform
LABS	Lattice Boltzmann Solver
LDV	Laser Doppler Velocimetry
LES	Large Eddy Simulation
LFL	Landing Field Length
LPA	Large Passenger Aircraft
MDO	Multi disciplinary Design Optimisation
NLDE	Non Linear Disturbance Equations
NLF	Natural Laminar Flow
OAD	Overall Aircraft Design
OGV	Outlet Guide Vane
PIV	Particle Image Velocimetry



RPM	Random Particle Mesh
RSB	Rotating Shaft Balance
SFC	Specific Fuel Consumption
SNGR	Stochastic Noise Generation and Radiation
TBL	Turbulent Boundary Layer
TF	Turbo Fan
TRL	Technology Readiness Level
TS	Technology Stream
UHBR	Ultra High Bypass Ratio
VTP	Vertical Tail Plane
WP	Work Package
WT	Wind Tunnel
WTT	Wind Tunnel Test
WT test HS	High Speed
WT test LS	Low Speed

II. Optimised Ice Protection Systems Integration in Innovative Control Surfaces

Leader and Programme Area [SPD]	AIR		
Work Packages (to which it refers in the JTP)	Novel Controls – A.4 Smart Mobile Control Surfaces – A-4.1 Optimised Ice Protection Systems Integration – A-4.1.x Advanced Engine Integration – A-1.1 Novel Certification Processes – A-1.4		
Indicative Topic Funding Value	5 M€		
Leading Company	Dassault Aviation, Airbus		
Duration of the action	8 years	Start Date	Jan 2015
Date of Issue	July 2014	Call Wave	1

Topic Number	Title		
JTI-CS2-2014-CPW01-AIR-01-02	Optimised Ice Protection Systems Integration in Innovative Control Surfaces	Duration	8 years
		Start Date	Jan 2015

Short description and terms of reference:

Increased awareness of real world icing conditions is the reason for the introduction of new performance standards in this area. Legacy systems are grand-fathered under the new set of rules, but new technologies and new approaches to development are required to escape technological stagnation induced by the indefinite reuse of solutions known since the seventies and before.

This topic addresses all the aspects of leading edge slat ice protection system technology, design and certification. For the next generation of jet transport airplanes the focus is on low weight and efficient use of energy. The B787 shows one possible implementation of a modern wing ice protection system, but icing is a bigger danger to smaller airplanes. Small business jets can have wing ice protection systems requiring the same amount of power as large airliners, but their engines and onboard power capability are much smaller. Further improvements are needed to decrease mass, decrease power consumption of anti-ice systems, and adapt them to a variety of other platform specific constraints, for instance air intakes of buried engines.

For the N+2 generation, this topic will continue the exploration of de-icing schemes which currently present significant technical challenges starting with the ability to create accurate computer models

of their operation. The goal would be to develop completely the processes and tools needed to optimise the design of such systems.

For the N+3 generation entering service in the 2030s, the topic will lay the foundation of radically new approaches to ice protection, offering opportunities to study technology with lower maturity.

The present topic is aligned to the strategic objectives of the Airframe ITD:

- *Reduce aviation environmental footprint, through advances in ice protection systems technology and integration aiming at saving weight at aircraft level. Lower weight aircraft will also have lower fuel consumption and emission levels;*
- *Help to improve mobility and decrease congestion, through novel ice protection systems covering Super Large Droplets and Ice Crystals conditions, allowing transport airplanes to fly safely in all weather conditions, and reducing weather related delays at airports;*
- *Set an active collaboration with the aircraft OEM and the large aero-structure supply chain around integrated platforms, as the proper integration of ice protection heaters and actuators in leading edges will bring together aircraft OEM, the manufacturers of these components and the aero-structure manufacturers in charge of integration;*
- *Contribute to European growth and to the preservation of highly skilled jobs thanks to advanced production processes and more efficient design, validation and certification processes, through the strong focus on modelling, experimental validation and high TRL deliverables.*

The topic contributes to the following technology streams:

- **Smart Mobile Control Surfaces (A4.1):** *the Core-Partner(s) will become leader of a work package which will deliver TRL 5 and TRL 6 slat demonstrators equipped with a mixed bleed / electro-thermal anti-ice system, in interaction with the airframers, the aero-structures manufacturers and the suppliers of all the components of the system. More distant goals would be to adapt the ice protection system operation to control surface position in order to save power.*
- **Advanced Engines Integration (A1.1):** *the engineering tools developed for wing ice protection systems will be used to address engine air intake ice protection systems. The work will focus on the buried central engine of a Falcon business jet. Interactions with airframers and engine manufacturers will be required to research synergies between the solutions to several technical challenges.*
- **Novel Certification Processes (A1.4):** *the ice protection topic lends itself well to indirect proof approaches proposed in this technology stream, since realistic icing conditions cannot be reproduced exactly in a wind tunnel for the entire flight in icing conditions envelope. The potential to use the same modelling approaches and tools for certification and system design activities will be examined in*



Topics for Core-Partners Call 1



connection with this technology stream.

1. Background

Airframe ice protection is a multi-faceted technology. Different strategies and technologies are applied to different surfaces requiring a form of protection. Smaller parts like air data system probes are usually electrically heated, even though measuring outside air temperature in a heated probe is challenging. On jet propelled airplanes, larger parts, like the engines and wings, are usually protected by hot air bled from the engine compressors. This method avoids power conversion and takes the power at the source, in the core of the turbine engine. Intermediate sized parts like the windshields can be protected electrically or using bleed air, depending on context.

On turboprops and piston engined airplanes, the engine core cannot accept large air off-takes and using too much electricity generates very heavy systems. Other ice protection technologies are employed to reduce the amount of power required.

There are basically two families of solutions in addition to power hungry thermal ice protection:

- Chemical protection, on the principle of de-icing installations used on the ground to prevent the accumulation of snow and ice on airplane wings before and during take-off. The de-icing fluids are alcohol based. Similar systems have been used on piston powered airplanes to protect propellers, windshields and more recently the wings using microdrilled titanium leading edge panels. These anti-ice systems become very heavy when there is a requirement to operate in icing conditions for a long time because the system consumes the anti-ice fluid. Although it is not a major source of pollution, the release of the fluid in the environment is also a cause for worry.
- Mechanical protection using a variety of principles, is historically performed using rubber de-icing boots covering the affected areas. The boots are inflated periodically with high pressure air taken from the engine. The rate of inflation is slow enough to accommodate engine capability. Electro-expulsive systems using coils to change the shape of the airfoil profile have also reached a high level of maturity. This change of shape is the main drawback of these systems, because boots in particular affect the aerodynamic performance of the profile. On fast jets, alterations to the wing profile can lead to significant reductions of the maximum lift coefficient, and would require two sets of certified landing performance data for flight in icing and non-icing conditions. For that reason electro-impulsive systems are in-development. The shape of the wing is also modified but the motion takes place with very high accelerations and imperceptible motion. It is also very fast. The goal is to fracture ice and eject it using its own inertia. Instantaneous power is very high, but the pulse is so short that overall, the system uses a low amount of power.

MAJOR PROTECTED AREAS IN AN AIRPLANE

This list gives only surfaces protected from ice resulting from the solidification of atmospheric moisture (water and water vapour). Ice is a concern for all water circuits and all circuits which can be contaminated by water such as fuel circuits.

- Wings leading edges,
- Wings upper surfaces in some conditions,
- Tail horizontal stabilizer and rudder leading edge (not always)
- Engine inlets, especially the front facing inlets in turbojet engines
- Windshields
- Antennas and probe

In relation with the airframe ITD, this topic focuses on the integration with wing leading edges and with the engine inlets of buried engines. The application case will be a three engine business jet, with a central inlet on the top of the rear fuselage and a long S-shaped duct supplying air to a central engine mounted in the tail cone.

OBJECTIVES AND FACTORS INFLUENCING THE CHOICE AND DESIGN OF ICE PROTECTION SYSTEMS

The current and the next generation of **high-performance & energy efficient** airplanes cannot tolerate wing profile contamination by ice when they come for landing in icing conditions and in other flight conditions which require the maximum performance of the wings. Therefore short term research will be focused on anti-ice systems, with a goal of a TRL 6 leading edge demonstrator no later than 2017.

The Core-Partner(s) will contribute to the development up to TRL 6 of an optimised thermal anti-icing system for a business jet. While it may not seem at first glance to push a power-hungry technology in the energy efficient activity line, this is justified by the necessity to use highly optimised wing profiles and the fact that the system is turned on during a short amount of time. Minimising the losses and the mass required to transport the power from the engines to the ice-protected areas will be an important concern.

The same technology can also be cost efficient, because it will have a low impact on mass and may not have high intrinsic costs. It could perform the ice protection function on the **highly versatile and cost efficient** airplane with low direct and indirect costs.

Even though commonality of :

- principles,
- design methods and tools, and
- technology

seems achievable across a broad range of aircraft, the final design and the technical feasibility are likely to be quite different. Indeed, the major factors affecting the design are:

Cruising Altitude:

Cruising altitude determines whether icing conditions can be encountered in cruise. Modern jet airplanes cannot encounter icing conditions in long range cruise because they fly very close to, or inside the stratosphere. In the stratosphere, temperature increases with altitude. This phenomenon eliminates the possibility of convective turbulence in this layer of the atmosphere.

This provides not just smooth flight conditions. It also limits the amount of water entering the stratosphere (some towering convective clouds still break in) and virtually eliminates any chance of icing conditions. Moreover, very cold temperatures are conducive to the formation of ice crystals, which pose a different threat to aircraft.

The amount of energy directly consumed by the system is usually not significant for long range jets, because the system is turned off most of the time. The focus is naturally on weight in this situation, because a low weight contributes to fuel savings in all the phases of flight.

Power Consumption Level and Profile

Of course, the average power consumption and some characteristics of the power consumption profile affect the size and complexity of onboard power sources. When it is turned on, the ice protection system is usually such a big power load, that engines incur very perceptible losses of performance, including loss of thrust. A power optimized ice protection system integrates well with onboard energy generation,

distribution and storage, has minimal impact on aircraft performance and engine operability, and provides for a minimized weight at aircraft level.

Airspeed

The airspeed at which icing conditions are encountered is also a major factor for systems which rely on a thermal effect to prevent ice build up or remove ice. Higher airspeeds improve convective heat loss on the protected surfaces, and a higher power is required to apply the correct temperature profiles.

There is a tripping point above which high speed low temperature relatively dry conditions dominate the power requirement and below which warmer, high liquid water content conditions dominate.

Kind of Icing Conditions the Airplane is Certificated to Fly Into

The kind of icing conditions the airplane is certified to operate in also has an impact. In 1994, the Roselawn landmark accident involved freezing rain, and subsequent tests demonstrated that the larger the droplets, the farther along the chord ice accretion can occur. Further research showed that droplets can be as large as 200 μm , while current certifications bases worldwide previously set the limit at 40 μm . This accident set airworthiness agencies into motion and led to new regulations on super large droplet conditions (SLD: freezing rain and freezing drizzle).

Properly designed and certificated airplanes can now be allowed to operate in such conditions. The trajectory of the bigger droplets of super cooled water in the aerodynamic field of the airplane is different in SLD conditions, and ice can accrete and grow on a wider set of airframe surfaces, which require adequate protection.

If the airplane cannot handle all conditions, the crew must be given the means, procedures or sensors, to accurately assess the conditions and plan a safe escape route if conditions degrade beyond the capability of the ice protection system.

Ice Detection System

Compatible ice detectors must be able to measure the rate of accretion and the size of droplets. If the airplane is not equipped for sustained flight in SLD conditions, the ice detector signal will

be used to tell the crew to escape. If the crew has no other mean to distinguish between conditions that can be handled by the airplane, and conditions that require an escape plan, the ice detection system must be a primary ice detection system.

A primary ice detection system can also be used to selectively allocate power either to extended areas corresponding to SLD conditions or to the smaller areas concerned by maximum rate of accretion conditions (SLD does not induce the maximum liquid water content – LWC). An aircraft equipped with less capable ice detectors may waste power by trying to simultaneously cover SLD and max LWC conditions which cannot coexist. However, the design of an ice protection system is always a trade-off between optimally low consumption and system complexity.

Protection Strategy

A protection strategy must be defined for each surface exposed to ice accretion. Aerodynamic performance and flying qualities must be taken into account when choosing the most appropriate strategy.

For some surfaces, ice accretion is acceptable and will only cause a slight and hopefully temporary increase of airframe drag. Ice bits shedding from these surfaces must not create a hazard for other parts of the airplane. This strategy provides the lowest ice-protection system mass, but various penalties can be incurred if ice cannot be cleared quickly after the icing encounter.

On other surfaces including wings, a limited ice build up may be acceptable. A de-icing strategy periodically ensures that thicker ice accretions are removed. Ice bits shedding from these surfaces have a predictable maximum size, and must not be hazardous to other parts of the airplane. This strategy normally provides the lowest power requirement in given icing conditions, since in the worst case, only a small fraction of the incoming ice has to be melted.

Some surface must be kept relatively clean all the time. Surface contamination by heavy rain is always possible and is not prevented by the ice protection systems currently in use. When the conditions lead to running liquid water on the protected surface the strategy is called “anti-ice running wet”. Water streams leaving the surface can freeze in tiny bits and hit other parts of the airplane including engines, where they must not be a hazard. Such systems seem to offer the best compromise between simplicity and power consumption, and can be designed using existing simulation tools. Running wet anti-icing technology must be ready for deployment on the next generation airplane, whose entry in service is in the early 2020s.

Finally, full evaporative anti-icing systems evaporate all the incoming water. They generate water vapour which eventually cools down and cannot be distinguished from existing components of the icing atmosphere. This approach uses so much power that it is not always practical, and the extremely high water contents associated with ice crystals conditions are particularly difficult to handle. This strategy is useful for engine air intakes, where flows of cold liquid water entering the engine could freeze inside the engine and make it fail. If it cannot evaporate all the water, the system must at least ensure that water will not freeze inside the engine.

Power Generation, Distribution and Energy Storage Technology

The ice protection system must remain operational with few restrictions in one engine inoperative (OEI) conditions.

Anti-icing systems use the largest amount of power but use it at a constant level. There is very little incentive to attempt an association with storage elements since the total energy expenditure is associated with worst case intermittent icing conditions, which are a natural phenomenon, which is not totally predictable. The power generation and distribution channels must be able to supply the maximum power the ice protection system requires in the corresponding environment conditions.

De-icing strategies are more likely to cycle power on and off as the system begins and terminates de-icing operations. The power profile is defined by the system and could have predictable peaks and troughs which can be covered by a battery. In that case, the engine driven power sources can be designed for an output only slightly larger than the average power consumption. The power generation channels shrink twice: once because de-icing systems intrinsically require less power than anti-icing systems, and a second time because when they are associated with storage elements, the power generation channels can be sized for the average power only.

The availability of high voltage DC or AC generation and distribution channels is essential to exploit the full potential of power extraction of the engines. A 12 kW 28V DC system uses a very large wire gauge to pass around 400A. 28V cannot be used for much higher levels of power. Without high voltage on board options are limited since only bleed can be used for the wings and other large protected surfaces. Lower voltage equipment tends to be heavier for a given power (up to the level at which insulation technology changes radically).

Simulation Tools

Current simulation tools can approximate the behavior of a de-icing system similar in design to the one onboard the French-German Transall military transport plane. The design opportunities are limited because they are 2D simulations. The fraction of design space which can be explored is limited to designs which can be "extruded" to a wing profile based on a 2D simulation model in the X,Z plane.

The optimization of system design must be performed manually: several options must be created, simulated and compared to check projected performance. The resource limits make it impossible to reach an optimum.

Ice fracture physics are not modeled properly, and existing tools only support thermal systems. None of the existing tools can assist the creation of optimum de-icing sequences under multiple constraints coming from power supplies and ice accretion constraints.

The simulations of future de-icing systems exist at a very early stage aiming to understand laboratory experiments only.

It is clear that the absence of flexible and reliable simulation and optimization tools currently limits the degree to which a design can be refined and optimized on computers. Unfortunately, icing wind tunnels cannot simultaneously recreate scaled aerodynamics and icing conditions, so

we are obligated to test at scale 1, but the icing wind tunnel is limited to low speed studies when large mockups are used. The computer simulations calibrated using low altitude icing wind tunnel data, must be used to extrapolate the system behavior in high speed, high altitude conditions.

Certification and Accepted Means of Compliance

Contributions to the development and adaptations of approved means of compliance regarding SLD and ice crystals conditions can help reduce technical design margins in the system.

2. Scope of work

Scope of work shall be to develop the following main activities/achievements:

- a. An electro-thermal and mixed air/electric running wet anti-ice wing inner section demonstrator, focused on a business jet wing with a polished aluminium leading edge. It will demonstrate the technologies and integration into wing structures required to achieve mass reductions at aircraft level, compared to a conventional full bleed system. The ice protection system operation shall be validated through tests in an icing wind tunnel at TRL 6. The final integration of heating elements in the leading edge will be performed by Dassault Aviation using heaters and electrical components supplied by the applicant(s). A sufficient number of heating elements, wiring sets and controller units will be produced to support IWTT tests, electrical integration on the Copper bird (with surrogate heaters) and a demonstration in flight.
- b. A theoretical and experimental study of manufacturing techniques, covering the consequences of assembly defects likely to occur in production, associated non-destructive control technologies and rework techniques whenever needed;
- c. Flat samples of various heating mat fabrications including polished aluminium erosion shield and heating element assembled using the same process as in the final leading edge. These samples will be subjected to direct lightning strikes in order to find how heating element materials behave when the wing is struck by lightning. The same samples will be used to measure and minimize the induced effects of lightning in the electrical circuits of the heaters.
- d. A 3D simulation of accretion and operation of a running-wet anti-ice system in the context of the air intake to the embedded central engine in a three-engine business jet. The demonstration of the simulation capabilities must include an adequate form of model validation, through an experimental test or comparison with actual flight test data for instance.
- e. Development of a TRL 5 prototype of a travelling wire bundle or similar device able to connect electrically the electrical heaters installed on a movable leading edge slat to the electrical harness installed on the wing box. The device will be tested in endurance by Dassault Aviation on a dedicated test setup.

- f. Integrate accurate models of ice shedding and ice fracture in general purpose ice protection simulation tools, and achieve the simulation capability of electro-thermal de-icing systems consistent with a development at TRL 4, and of electro-mechanical de-icing systems consistent with a development at TRL 3 ;
- g. Taking into account optimized electrical power system components developed in the SYSTEMS ITD, the applicant(s) shall perform a study aiming to discover which electric architecture simultaneously complies with all the power availability requirements common to all large jets, including engine and alternator failures, and yields minimum mass at aircraft level in conjunction with a suitably designed ice protection system;
- h. Innovative materials and coatings for surfaces equipped with passive ice protection. The proposed technologies must improve either maximum ice thickness, nature of ice, size of shed ice blocks, resistance to ice accretion, ... Some ice protected surfaces are the surfaces which are the most subject to erosion. Durability of coatings and materials will necessarily be part of these studies. Application of these technologies in conjunction with de-icing or anti-icing strategies on surface less subject to erosion, will be studied and the associated gains at aircraft level quantified.
- i. A technology down-selection process applied to breakthrough approaches to ice-protection which offers more than tenfold reduction in power consumption allowing significant mass savings at aircraft level for jets entering service in the 2030s.

3. Special skills, capabilities - See list under Paragraph II

4. Major deliverables and schedule (estimate)

Due date is year-end unless indicated otherwise.

When the deliverable is a validation, the deliverable is a report of the successful validation tests or simulations.

For experimental validations, physical tests on implementations at the required TRL level are required, and the deliverable is the test report containing test configuration, with details on the test article, test procedures and raw test results, plus the analysis of the tests and the justification for a "test passed" synthesis.

When the deliverable is a validated item, the item itself shall be delivered, after it successfully passes the tests specified in the manufacturing control sheet and/or acceptance test procedure and/or validation tests.

When the deliverable is a model, it will be delivered on a computer readable support or via an upload on a dedicated server shared with Dassault Aviation and Airbus, with a document containing the complete documentation of the model down to the physical equations and physical phenomena represented, unless the model is delivered in unencrypted, properly documented and quality-checked Modelica code, in which case only a summary document is required. In both cases, running test cases and the corresponding reference results will be delivered and will cover (1) all the components of the model, (2) all the required use cases.

When the deliverable is a TRL milestone, all the corresponding proofs will be at the disposition of Dassault Aviation and Airbus for review with the Core-Partner(s), and the deliverable will be complete when all the commonly accepted TRL 2 criteria are passed.

When initial production samples are requested, they are usually small flat square samples of the processed material. At least one sample per involved leader must be planned in addition to samples kept by the Core-Partner(s).

The yearly progress reports will be delivered as a draft 6 months before the due date, and the draft and final report due dates will be set according to the global Clean Sky 2 requirements set by the CS2JU. These reports will feed the periodic reporting of CS2 activities to the CS2JU.

Deliverables			
Ref. No.	Title – Description	Type	Due Date
AIR-W1ST2-1	Validated inner wing leading edge running wet mixed energy thermal ice protection system demonstrator at TRL 6. Validation will be based on icing wind tunnel tests in realistic conditions, and the design validated at TRL5, the production process & control sheets and the tooling will be supplied by Dassault Aviation.	RTD	2016
AIR-W1ST2-2	Manufacturing of defective leading edge skin stack up flat samples and experimental assessment of consequences. Validation of : - the need to rework each type of defect, - when the defect cannot stay in the part, - the non-destructive control equipment capable of finding the defect and, - the production process for the rework activity itself	RTD	2015
AIR-W1ST2-3	Tests of direct lightning strike on aluminium erosion shield of samples and insulation material recommendation. Characterisation of lighting aggression on heater electrical circuits.	RTD	2015
AIR-W1ST2-4	Falcon S-duct ice protection system simulated in 3D using either validated 3D ice protection system modelling tools, or a well-defined and managed process in conjunction with 2D tools.	RTD	2016

Deliverables			
Ref. No.	Title – Description	Type	Due Date
AIR-W1ST2-5	Experimental validation of a travelling wire bundle device capable of reliably bringing electrical power to a movable leading edge slat. Should no suitable TWB device be available, the development of the device up to TRL 5 minimum is in the scope of the activity.	RTD	2016
AIR-W1ST2-6	Ice dust / ice sand engine ingestion validation. An adequate plan to validate that ice dust and ice sand produced under some circumstances by a running wet anti-icing system is not harmful for selected engine types, will be proposed and implemented.	RTD	2016
AIR-W1ST2-7	Review of potential materials and coatings for advanced ice protection systems - wave 1	RTD	2016
AIR-W1ST2-8	Demonstration of accurate simulation of a thermal de-icing system during its entire operating cycle in various icing conditions.	RTD	2017
AIR-W1ST2-9	Experimental validation of a TRL4 laboratory mockup (brassboard) of a de-icing wing ice protection system.	RTD	2017
AIR-W1ST2-10	Experimental assessment of the ice bridging phenomenon in relation to delayed activation and parting strip width, and comparison with simulation results. Updates to simulation codes and/or their user manuals to properly account for the experimentally observed phenomena, are in the scope of this deliverable.	RTD	2017
AIR-W1ST2-11	Innovative business jet electrical architecture and its model in Modelica, compatible with airframer energy budget and component sizing tools.	RTD	2017
	Innovative large A/C electrical architecture and its model in Modelica or SABER, compatible with airframer energy budget and component sizing tools.	RTD	2017
AIR-W1ST2-12	Manufacturing production sheets for selected wave 1 materials and coatings, and a number of initial production samples.	RTD	2017

Deliverables			
Ref. No.	Title – Description	Type	Due Date
	TRL 3 milestone for a de-icing wing ice protection system demonstrator for large A/C & Decision gate for transfer of the activity within LPA for maturation of the technology	RTD	2017
AIR-W1ST2-13	Review of potential materials and coatings for advanced ice protection systems - wave 2	RTD	2018
AIR-W1ST2-14	Test results for wave 1 materials and coatings	RTD	2018
AIR-W1ST2-15	TRL 2 milestone for a Breakthrough ultra-low power ice protection system demonstrator for business jet	RTD	2018
	TRL 2 milestone for a Breakthrough ultra-low power ice protection system demonstrator for large A/C	RTD	2018
AIR-W1ST2-16	Demonstration of accurate simulation of a mechanical de-icing system during its entire operating cycle in various icing conditions producing all natures of ice.	RTD	2019
AIR-W1ST2-17	Manufacturing production sheets for selected wave 2 materials and coatings, and a number of initial production samples.	RTD	2019
AIR-W1ST2-18	TRL 3 milestone for a Breakthrough ultra-low power ice protection system demonstrator for business jet	RTD	2020
	TRL 3 milestone for a Breakthrough ultra-low power ice protection system demonstrator for large A/C & Decision gate for transfer of the activity within LPA for maturation of the technology	RTD	2020
AIR-W1ST2-19	Test results for wave 2 materials and coatings	RTD	2020
AIR-W1ST2-20	TRL 4 milestone for a Breakthrough ultra-low power ice protection system demonstrator.	RTD	2022
AIR-W1ST2-R1	Yearly progress report on all open tasks.2015.		2015
AIR-W1ST2-R2	Yearly progress report on all open tasks.2016.		2016
AIR-W1ST2-R3	Yearly progress report on all open tasks.2017.		2017
AIR-W1ST2-R4	Yearly progress report on all open tasks.2018.		2018
AIR-W1ST2-R5	Yearly progress report on all open tasks.2019.		2019
AIR-W1ST2-R6	Yearly progress report on all open tasks.2020.		2020

<i>Deliverables</i>			
<i>Ref. No.</i>	<i>Title – Description</i>	<i>Type</i>	<i>Due Date</i>
AIR-W1ST2-R7	Yearly progress report on all open tasks.2021.		2021
AIR-W1ST2-R8	Yearly progress report on all open tasks.2022.		2022
AIR-W1ST2-FR	Strategic Topic Final Report		2022

III. New Wing and Aircraft Systems Design and Integration for Turboprop Regional Aircraft

Leader and Programme Area [SPD]	AIR		
Work Packages (to which it refers in the JTP)	B.2.2 / B.3.2 / B.3.3		
Indicative Topic Funding Value	5 M€		
Leading Company	EADS-CASA		
Duration of the action	7 years	Start Date	01/01/2015
Date of Issue	01/06/2014	Call Wave	1

Topic Number	Title		
JTI-CS2-2014-CPW01-AIR-02-01	New Wing and Aircraft Systems Design and Integration for Turboprop Regional Aircraft	Duration	7 years
		Start Date	01/01/2015

Short description

The EADS-CASA FTB2 demonstrator will show CORE technologies to be implemented in Future Regional Aviation: carbon fiber low weight structures, new control concepts for control surfaces and highly advanced Loads Control device all able to reduce structural weight / fuel consumption reduction/ increase of a/c performance.

Within Airframe ITD there are several technology streams devoted to integrate systems within this type of new structure or alleviate loads being focused in flight control, SATCOM antenna, ice protection, landing gear and electrical supply.

The Strategic Topic is to endow the team with an enabler able to understand the needs for integration and go further with some components which will be even integrate within the structure. The Core-Partner(s) will contribute as follow:

- Participate with WAL in the preliminary studies related to integration
- Detail design of elements
- Perform some validation/verification testing prior to flight tests
- Deliver elements to FTB2 demonstrator in the Regional Aircraft IADP

Since demonstrations will reach flight testing the applicant(s) shall have a proven experienced capability (based on historical antecedents) in the fields of systems and technologies within this call



Topics for Core-Partners Call 1



and to design components which are installed in prototype airplanes with Permit to Fly requirements.

In addition, the Core-Partner(s) is (are) requested to manage Call for Proposals in agreement with EADS-CASA to achieve the final aim of this Call.

1. Background

In the framework of Clean Sky 2 Airframe ITD, the Call requires Core-Partner(s) (company or consortium) to provide concurrent engineering to the Work Area Leader (WAL) EADS-CASA in the area of complex systems integration in innovative airframe structures. **The technological lines will extend from design phases to delivery of highly integrated systems in innovative airframe structures.** The TRLs required will allow the Clean Sky 2 Regional Aircraft FTB2 demonstrator a flight test campaign in the Regional Aircraft IADP.

The **Core-Partner(s)** need(s) to manage components of systems in the aircraft with strong links with **WAL activities and other Partners** who will work in technology lines of aircraft design, structures and new assembly processes. The sketch below shows technology lines involved in the Call and their relationships among them and the rest of technologies of **Airframe ITD and Regional Aircraft IADP**. The systems will “work together” embedded and affecting the aircraft wing structure.

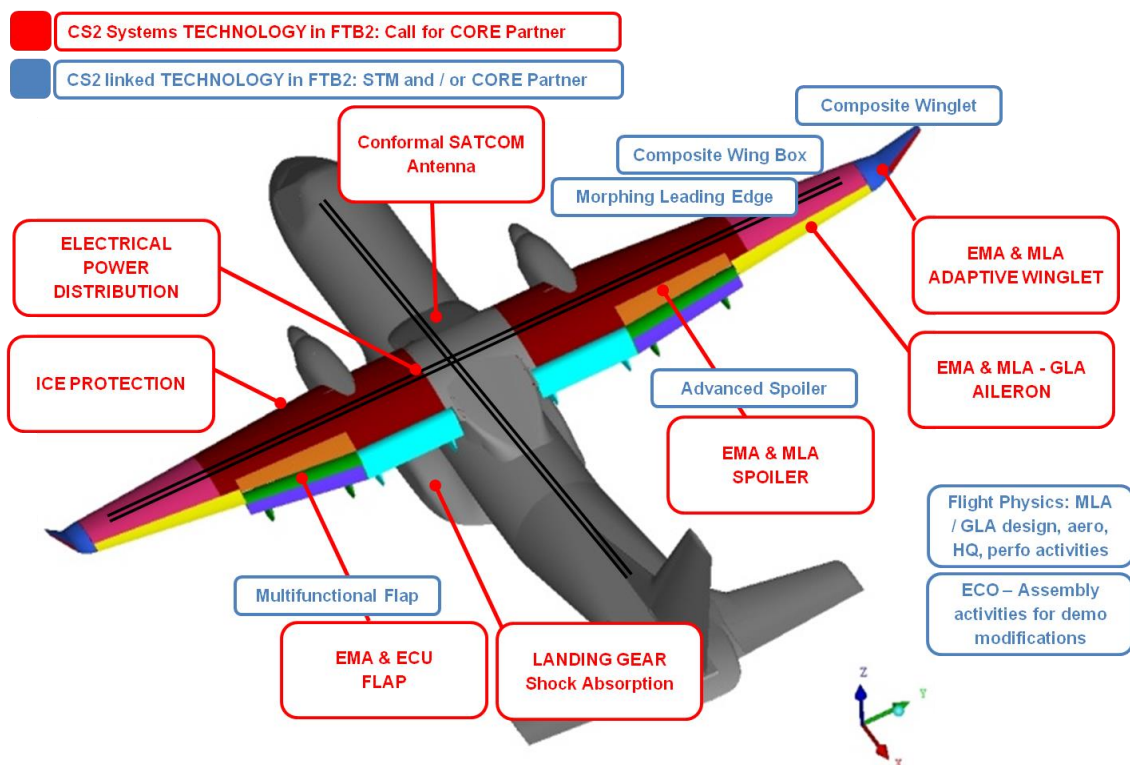
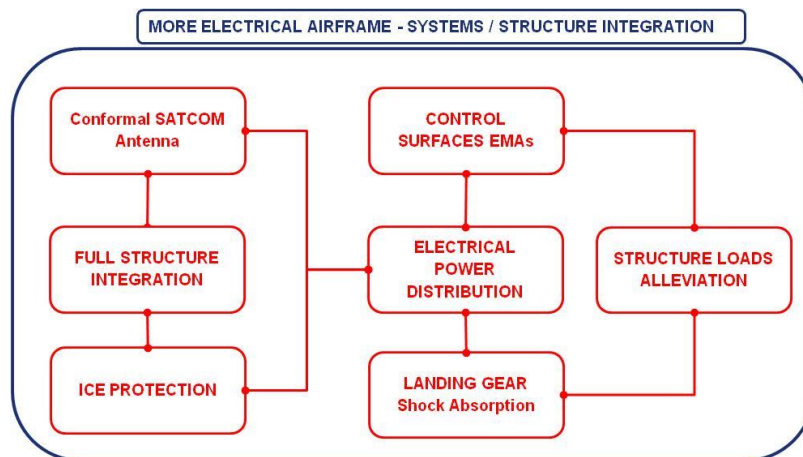


Figure 1. Regional Aircraft FTB2 Structural and Systems Technology links

Clean Sky 2 targets will be fulfilled with innovative structures, optimized according to multidisciplinary overall aircraft design and supported in highly integrated systems. The technology lines are interconnected in a system-of-systems philosophy with the aim of reaching TRL for flying

the demonstrator. For instance, the concepts of **conformal antennas** and **ice protection** systems will be fully integrated in carbon fiber aircraft structures along the wing; the **electrical power distribution** will be able of supplying power to all the aircraft; the **electro-mechanical actuators** in control surfaces will play a key role for alleviating flight loads of the aircraft while the **landing gear shock absorber** technology will do it on ground.



The background of the technology lines is the current state of the art in **aircraft systems integration within airframe**. In many cases the actual TRL was fixed in Clean Sky or other national technology programs (i.e. electromechanical actuators for control systems and landing gear and new electrical distribution), in other cases specific companies' research lines (i.e. conformal antennas and ice protection systems). However the target within the Clean Sky 2, and in particular in this Call for Core-Partner(s), is to achieve the latest states of TRL to allow a Permit to Fly of the FTB2 demonstrator. One of the objectives of **Green Regional Aircraft (GRA)** in **Clean Sky** was the technologic evaluation of **electromechanical actuator** and associated control electronic able to comply with requirements for use on a rudder surface in active-standby configuration with other redundant actuator. The step forward of this Call is to demonstrate and consolidate the use of EMA in wing flight control surfaces with more severe high level requirement such as high duty cycles, system criticality etc. Additionally, in **Clean Sky**, **HVDC electrical supply** was considered for non-essential loads, meanwhile the solution proposed by the WAL (EADS-CASA) needs a next step to supply essential loads like those of flight control actuators. Technologies from Clean Sky and National Founded (i.e. FT4B) programs will serve as foundations to achieve the TRL required in the Call for Core-Partner(s).

The **electromechanical actuators for aircraft control systems (EMAs)** is an essential system for the load alleviation systems (MLA and GLA) which allow structural optimization of the whole wing by means of this active system. An example of the current state of the art of this technology is a EMA rudder actuator of the GRA in active-standby configuration with other redundant actuator. The step forward is the use of EMA on wing flight control surfaces with more severe high level requirement level such as high duty cycles, system criticality etc. The **technologies of landing gear** are focused in

systems which may improve the measurement of ground loads (SHMS sensors) and act as active systems to reduce loads (magnetorheological fluids modulating viscosity) in different conditions.

The **conformal antennas** and the integrated **ice protection systems** are technology lines where the integration of the system embedded within the carbon fiber structure is essential. The proposed conformal and distributed SATCOM Ka band antenna will extend the aircraft communication capacity but without any additional protuberances in the structure which increase loads, weighs and aerodynamic performances. On the other hand, the ice protection systems where physical properties of the materials allow the parts to act as structure, aerodynamic shape and system are very promising.

Finally, a common system of **HVDC (High Voltage – Direct Current) electrical power supply** of all the aircraft is proposed for essential loads. This system will be a step forward in the current state of the art in Clean Sky where only non-essential loads were considered. The interfaces of this electrical system with many others in the aircraft are a challenge in Clean Sky 2. The need of a new Electrical Power Distribution in regional aviation comprehends: minimal voltage drops, minimal risk of safety issues from leakage currents, minimal risk of nuisance trips from lightning strikes and minimal risk of damage from high inrush currents. Silicon carbide power semiconductors can enhance this performances comparing with existing Silicon devices.

2. Scope of work:

GENERAL

The scope of the work within this topic is the design, manufacturing and qualification, of certain component and equipment (in particular flight controls, electrical supply, SATCOM antenna, landing gear and ice protection) for the more electrical high lift wing regional aircraft by EADS-CASA in the Clean Sky 2.

Although the works within this call will be done in the Airframe ITD, all equipment (except those for ice protection) will be flight tested on the IADP Regional Aircraft FTB2.

The Regional Aircraft FTB2 is a prototype aircraft based on the EADS – CASA C295 model. This aircraft is Civil FAR 25 certified by FAA and EASA Airworthiness Regulations with large in-service experience as regional aircraft which is a perfect platform to test in flight CleanSky 2 technologies.

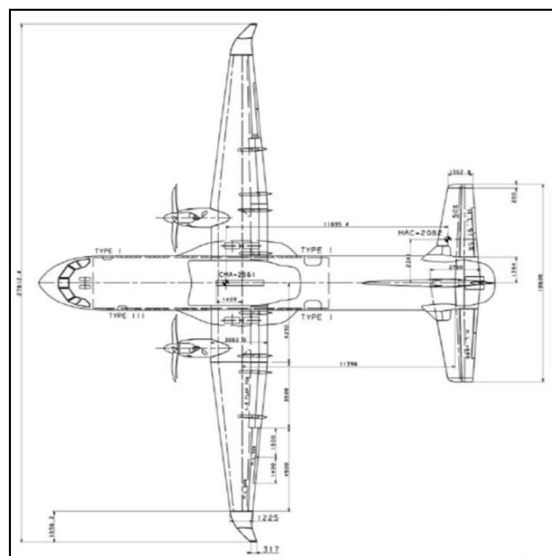


Figure 2. Regional Aircraft FTB2: EADS-CASA C295

The applicant(s) shall have a proven experienced capacity (based on historical antecedents) in the fields of equipment and technologies within this call and to supply them so can be installed in a prototype airplane with permit to fly. Quality of materials and of processes shall be assured to support the final assembly in the demonstrator.

EADS-CASA will request to the Airworthiness Authorities (European) a Permit to Fly for the Regional Aircraft FTB2 with all technologies matured in the Clean Sky 2. The CP will support this process, being mandatory for that the following activities:

- Calculation processes/tools validated and harmonized with EADS-CASA

- Delivery of equipment with appropriate Certificate Of Conformity and documentation (including Declaration of Design and Performance) to obtain aircraft permit to fly (estimated date June 2019).
- Material data, processes and tools allowing installation in aircraft.

Support is also expected of the Core-Partner(s) during the flight test campaign providing adequate response to solve any non-expected issue or failure of the equipment. Provisions for spare equipment shall be accounted and declared by the Applicants.

The Core-Partner(s) will provide the achievements with respect to Horizon 2020 and ECO-design objectives along the program. The results of the works need to be evaluated in terms of environmental and productivity objectives aligned with Clean Sky 2 strategy (CO₂ and NO_x emission reductions, fuel consumption efficiency and noise footprint impact) versus the current existing ones technologies. These studies will be assessed during all the project duration into the different Quality Gates (QGs) that will be performed. A special report focus on this aim will be performed by the WAL and CP.

Technology Roadmap

The Call for Core-Partner(s) is organized in five main work packages. The status of every technology line will evolve during the program to reach in one hand maturity for being tested in – flight and in the other hand, the required level of integration between lines in the aircraft. A global technology roadmap shows targets in TRLs along the project considering all technology lines and full integration within among them and in the Regional Aircraft FTB2 demonstrator.

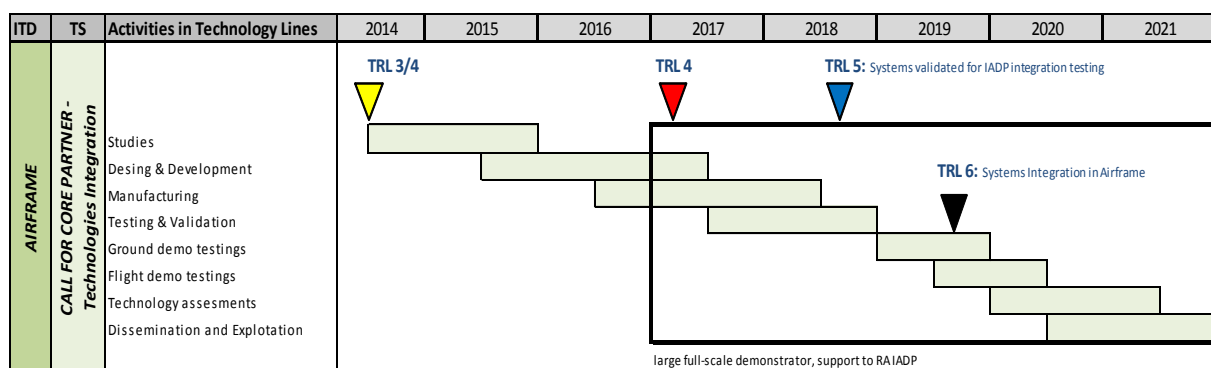


Figure 3. Regional Aircraft FTB2 Global Technology Roadmap

Common Test Strategy

The common test strategy of every technology line is collected in the following table which contains activities, prototypes, tests, facility requirements and responsible.

Technology Lines	Technologies Demonstrators	Testing activities & facilities	Respons.
Flight Control Actuation Systems (Aileron, spoilers, winglets & flaps Driven by EMAs)	Prototype equipments actuator EMA & control unit (ECU)	Laboratory test at CP facilities Static and functional & qualification tests	CP
	Prototype Actuation System actuator+ control unit integrated with the real Flight Control Computer (FCC) in the actuation system integration Rig.	Laboratory Test at WAL facilities in the actuation System Integration Rig. System integration & functional test (operational models, normal/failure)	WAL CP Support
	Prototype System installed in Aircraft actuator+ control unit integrated in aileron and connected to FCC.	Aircraft Test at Regional Aircraft (FTB2) Ground Test Static functional & Certification test for permit to flight Flight Test validation test	WAL
	System Simulated environment actuator EMA & control unit (ECU) simulation mode to be integrated in the actuation system Model	- EMA + ECU Model provided by CP. - Aileron actuation System Model provided by WAL, validated against qualification and validation tests.	CP WAL
Technology Lines	Technologies Demonstrators	Testing activities & facilities	Respons.
Electrical power distribution for actuation system	Prototype equipment Electrical distribution unit 1 unit for rig & 2 units qualified for A/C	Laboratory test at CP facilities - Functional test - Qualification test (EMC, environment)	CP
	Prototype electrical system Distribution box (rig unit) integrated in the “electrical system integration rig” (generator + converter +loads)	Laboratory Test at WAL facilities in the electrical System Integration Rig. System integration & functional test	WAL CP Support
	Prototype System installed in Aircraft distribution box (A/C unit) installed in the A/C and integrated with the flight control actuation system	Aircraft Test at Regional Aircraft (FTB2) Ground Test Functional test & Certification test for permit to flight Flight Test validation test	WAL
	System Simulated environment distribution unit simulation model to be integrated in electrical system Model	- Distribution Model provided by CP. - Full electrical System Model validated against qualification & validation tests (WAL)	CP WAL
Ice Protection system highly integrated in structure (induction & two phase)	Prototype Component Anti-ice tech solution integrated in a representative surface (2 m ref length) provided by WAL.	Laboratory test at CP facilities in a functional rig Functional test	CP
	Prototype anti-ice system Prototype component integration in a representative surface (2m ref length).	Icing tunnel test at partner facilities Functional test of system performances under simulated ice conditions Vibration tests (only two phase tech)	Partner WAL

Technology Lines	Technologies Demonstrators	Testing activities & facilities	Respons.
SATCOM Antenna highly integrated in structure	Prototype Antenna Components RF unit (radiating elements, amplifier..etc) integrated in a representative surface	Laboratory test at CP facilities in a test bench - Functional test - Qualification test (environment: T, vibr, ...)	CP
	Prototype Antenna System installed in A/C highly Integration of antenna system into airframe structure	Aircraft Test at Regional Aircraft (FTB2) Ground Test Functional test & Certification test for permit to flight Flight Test validation test	CP
Landing Gear Technologies	Prototype LG component instrumented bolt Elect. valve and Shock absorber	Laboratory test at CP facilities Static and functional test	CP
	Prototype LG Actuation System LG component integrated in the LG system integration Rig.	Laboratory Test at WAL facilities in the current LG System Integration Rig. System integration & functional test	WAL CP Support
	Prototype System installed in Aircraft only instrumented bolt technology is installed in the Landing Gear (CP)	Aircraft Test at Regional Aircraft (FTB2) Ground Test Static functional test Flight Test validation test (Taxi, T/O & Landing (only WAL)	WAL CP

Activities of Core-Partner(s)

In general, the main activities to be performed by the Applicant are the following:

1. Support to WAL in performing the trade-off between different alternatives for selection of the architecture of the system and structure.
2. Detailed specifications and requirements of equipment based from the high level requirements received from WAL.
The requirements by the WAL will include, mission definition, operation modes, installation, electrical, mechanical and control requirements, fatigue, endurance, weight, stiffness, qualification, etc.
Support to the definition of requirements to the structure with which there will be interdependencies.
3. Preliminary definition of equipment in order to achieve the selection of the optimal solution. It will define the integrated concept of the equipment.
Detailed aircraft interface requirements will be received from WAL to define the solution.
This WP will finish with a preliminary design review (PDR).
4. Detailed design of equipment.
This WP will finish with a critical design review meeting (CDR).
5. Validation and Qualification Test Plan Definition of the equipment
It will define all the related activities aim to demonstrate the functional validation and qualification and Test Rig validation according to the specifications.
6. Definition of Laboratory Test Bench Specification

This activity, to be performed jointly with WAL will define the laboratory benches minimum requirements in terms of capacity, size, data to be registered and so on.

7. Manufacturing, Assembly and Tuning of equipment.
8. Validation and Qualification Tests realization and results.
9. Component documentation and support to obtain the FTB2 Permit to Fly from Airworthiness authority (European).
10. Support to flight testing campaign.

The applicant(s) shall detail for each of the projects the **detailed list of activities** and the **topics** to be launched with **Call for Proposals** (including budget – respecting 4 M€ maximum- and integration with respect to the complete plan of the Call for Core-Partner(s)).

ELECTROMECHANICAL ACTUATORS FOR AIRCRAFT CONTROL SYSTEMS

The main objective of this technology line is to gain maturity in flight using electromechanical actuator as power devices to drive primary control surfaces as well as active loads reduction controls or morphing systems in the wing for the regional aircraft to be tested in FTB2.

Primary (ailerons and spoilers) and secondary (Winglet and Flap) flight control surfaces will be aerodynamically optimized (in terms of shape, size slots, kinematics, gear ratio, rates, etc) following the all electric aircraft principle.

Under the general concept of using different movable / morphing surfaces to enhance the aerodynamic behaviour of the wing of a regional aircraft, several technology proposals have been selected for demonstration in Cleansky2 Airframe ITD:

- Winglet installation to enhance drag performance.
- Integration of active loads alleviation functions (Manoeuvre Loads Alleviation MLA and Gust Load Alleviation GLA) by using ailerons and spoilers driven by EMA's. Evaluation of the contribution of symmetrical motion of flap to MLA.
- Optimization of take off, Climb, Descent and approach performances by using airbrakes, continuous Flap setting and active tab flap.

The optimization of aircraft will be done by the WAL considering criteria of over all aircraft design (OAD) like aerodynamics (CFD, WTT and flight tests), handling qualities, loads and loads alleviation systems. The CP will support the process to add value in the systems required.

The implementation of the EMAs in the Primary Flight Control System is an innovative approach because there are not in the market solutions based exclusively on electric technology.

The technological solution high level specifications are:

- Electromechanical Actuators EMA (270 VDC) and its related actuator control electronic ACE (28 VDC) for use in ailerons and spoilers. Able to implement position, torque and speed control loops and providing position, torque and speed feedback. Aileron range +/-25°, Spoiler range 50°, stroke 50 mm, 1000 N.m hinge moment per surface.

- Electromechanical Actuators EMA (28 VDC or 270 VDC) for flap tab motion with integrated position control and position feedback. Flap tab range 40°, stroke 100 mm and 4000 N stall load. (Note: this actuator IS NOT the flap extension / retraction one, but the corresponding to the flap leading edge tab).
- Electromechanical Actuators (28 VDC or 270 VDC) for winglet tab motion with integrated position control and position feedback. Winglet tab range +/-30°, stroke 50 mm and 1000 N stall load.
- Flap Electronic Control Unit for continuous flap setting with interface compatible with the current FT2B Flap Control System.

Conceptual design of the component will be provided by the WAL, meanwhile detail design, sizing, parts manufacturing, quality assurance and low level tests are responsibilities of the CP.

The number of specimens to be delivered should be:

- A complete ship set for use in the airframe test rig. It is to say: 2 EMA + 2 ACE for ailerons, 2 EMA + 2 ACE for spoilers, 2 ESVA + 2 PFACE for ailerons, 1 FECU.4 EMA's for Flap Tab, 2 EMAs for Winglet Tab.
- A complete ship set for use in the FTB2 aircraft.

The Flight Control System equipment required within the framework of this Call for Core-Partner(s) will be installed in the wing of the Regional Aircraft FTB2, of reference length 13 m.

The main equipments are shown in Figure 4 (only right hand wing is shown but will be also in the left hand wing, ECU is one per aircraft).

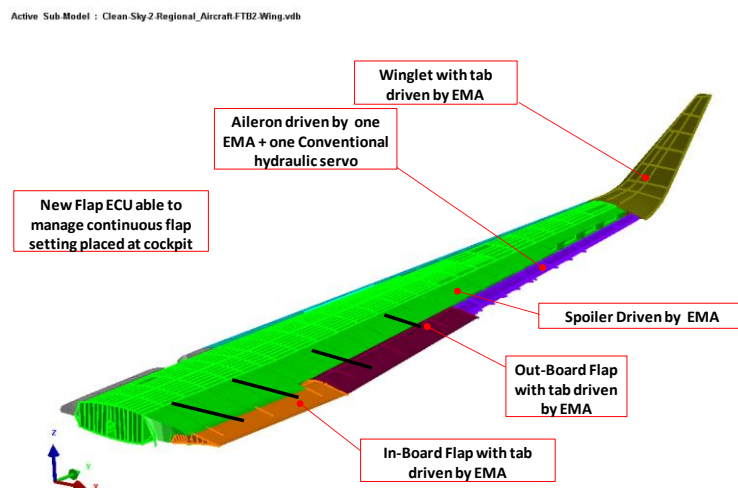


Figure 4. FCS equipments to be supplied by Core-Partner(s).

The Core-Partner(s) shall explain its proposals of equipment and also perform a risk and mitigation analysis which includes back-up technologies in case the selected ones could not reach initial expectations.

CONFORMAL & DISTRIBUTED SATCOM KA-BAND ANTENNA

The objectives of this technology line are:

- Eliminate the aerodynamic drag associated to the current state of the art airborne SATCOM Ka band antenna solutions, based on large apertures and covered by bulky radomes, by using an electronically steerable antenna integrated into airframe structures.
- Ensure the high data rate radio link regardless the aircraft's attitude or latitude. To ensure proper antenna performances within sector of interest using electronically steerable antenna type, a distributed concept in different airframe structures is proposed. Several arrays apertures located in different aircraft positions will allow switching or combining the suitable elements in order to cover the sector of interest ensuring most optimum system performances; i.e. high data rate radio link.
- Demonstrate the viability of using airframe structures to integrate complex antenna systems, satisfying both structural and system functionalities.

The conformal and distributed SATCOM Ka-band antenna system shall be composed of the following elements:

- Two (2) Antenna Aperture and KRFU (Ka band Radio Frequency Unit) Sets: these sets or equivalent concept including the radiating elements, amplifiers, mixers, phase shifters and distribution feeding networks will be integrated, one set in the forward Wing To Fuselage Fairing (WFF) panel and other in the rearward Wing To Fuselage Fairing (WFF) panel (see Figure 5). The resulting design shall be conformal to the structure in order to eliminate on-aircraft aerodynamic impact. The WFF panels shall be designed to perform their proper functions as structure, and additionally to allocate the aforementioned antenna elements (see Figure 5). Special attention shall be paid during the design phase for aspects like stiffness, thermal dissipation and vibrations; critical for proper antenna beam forming.
- One (1) KANDU (Ka band Network Data Unit): this unit receives the aircraft's attitude and the satellite services database, with such data the steering algorithm must ensure the enough accuracy to aim the antenna beam into the Geo Stationary Orbit location and to avoid interferences with other satellites.
- One (1) Modem: This equipment receives the radio link channel status to change the modulation (Adaptive Code Modulation) and manage the base band contents (e.g. Wi-Fi, Ethernet, In Flight Entertainment contents).

Main technological challenge is linked to antenna aperture and KRFU set and its integration into airframe structure. As an aim of design, the same set must be usable for forward and rearward WFF panel. KANDU and Modem activities should be reduced to modify existing equipment in the market, when feasible.

The antenna shall operate at Ka band (20 GHz for reception and 30 GHz for transmission) and shall be able to establish high data rate satellite communications. Thus, the antenna must operate under the specific ITU regulation to ensure interoperability. The conformal antenna is fully integrated in the area of the wing – fuselage fairing (forward and rear) with no additional protuberances respect to actual aero - configuration. Reference sizes of antennas are 400 x 800 mm and details of the integration are sketched below. Sizing loads are expected to be similar to those in the actual demonstrator: reference acceleration level is 6.5 g's at cruise.

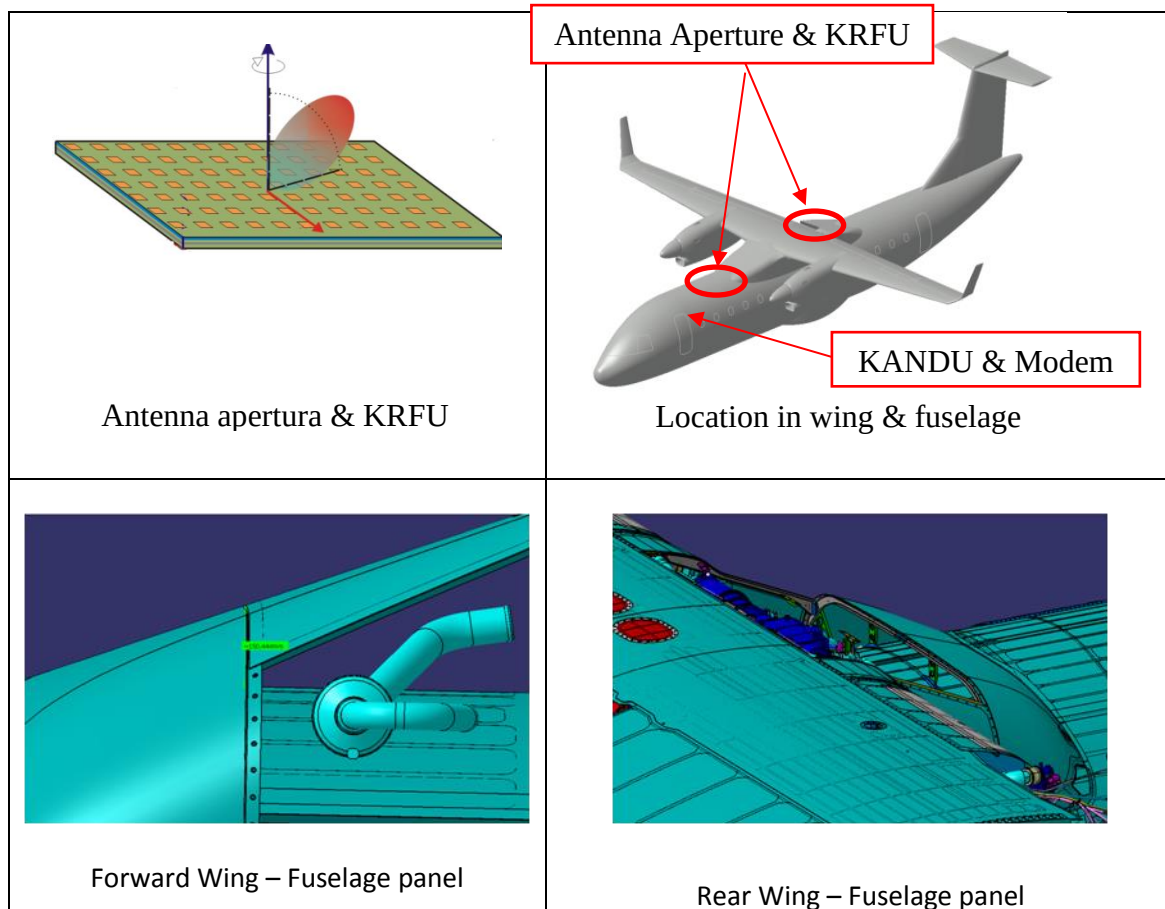


Figure 5. Antenna Installation in Aircraft

Conceptual design and integration, including manufacturing and testing of antenna aperture and KRFU into the WFF panels shall be carried out by the WAL & CP.

For the rest of equipment, the CP shall be fully responsible of its design. A laboratory test bench shall be defined between WAL & CP, meanwhile CP shall be responsible of the integration and test of all the antenna elements.

WAL shall provide to CP all the technical information required for a suitable design, integration and test of the antenna system in the FTB2 Regional aircraft. Furthermore, for its installation and test in

the FTB2 Regional, CP shall provide all those evidences required by the WAL and/or the European Certification Authority to support the clearance for 'Permit to Fly'.

Following is a list summarising the technological solution, technology challenges and technology demonstrators with associated hardware deliverables from CP.

ELECTRICAL POWER DISTRIBUTION FOR ESSENTIAL LOADS

The main objectives of the HVDC distribution system which provide electrical power to the flight controls are:

- Providing power at 270 Vdc to essential loads (EMAs that govern the aircraft control surfaces) with the required safety level of criticality.
- Integration of all specific HVDC protection systems (against arc fault, Partial discharge, etc...)
- Research new algorithms for Electrical Energy Management in Generation and Distribution systems that minimize the power budget, and therefore, the weight of the generators.

Accordingly to promising advances in current simulation tools, a parallel process of modelling and simulation, exploring new simulation and testing strategies can help to reduce and mitigate possible project risks and to anticipate deviations of performances in the early stages of the project. .

Once analyzed the safety requirements of FCS, the solution for the HVDC Distribution System will be focused on:

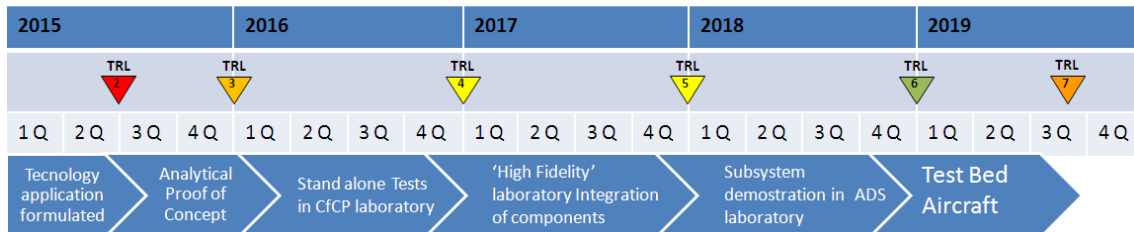
- Evaluate the state of the art in energy management systems in commercial aircraft products and those achieved in R&D projects to establish which ones are to be considered, focusing in the safety requirements of this project.
- Define a distribution system in HVDC with its corresponding system algorithms including reconfigurations (according with loads safety requirements) and intelligent Energy Management concepts that guarantee a smart use of energy.
- A reduction in the weight of the aircraft means an increment in the power density. This can be achieved using improved magnetics and semiconductors like Gallium Nitride (GaN) or Silicon Carbide (SiC), enabling high switching frequencies resulting in small passive components and improved EMI properties.

Such applications require solutions that go beyond the structural modification of the devices or new gate actuation. A promising alternative is to build devices based on carbide silicon (SiC), that have promising applications in high temperature and high power environments, like engines, oil-wells for power conversion and sensor application.

The specific technology roadmap for this system will cover from the concepts until the installation within the FTB2 demonstrator and verification with flight tests. The ground tests in the CP facilities and in the WAL facilities at global integration level are a previous step to fulfil evidences to obtain a Permit to Flight with Airworthiness Authorities. In fact certification requirements will be as a target in the technology line for further exploitation of the program.

Electrical power distribution for essential loads Roadmap

SiC Technology



Obtain electrical behavioural simulation Models with the “SABER” simulation tool and adjust it during all the program progress, to support the securing of the FTB2 permit to fly and assure the similarity of models behaviour against real systems in order to extrapolate results.

From the point of view of embedding the Power Supply system in the aircraft, potential locations are identified in the fuselage underfloor within an approximate space of 450x550x400mm for the whole system (including distribution box, harnesses, mounting tray and installation and maintenance tasks requirements).

The main technology challenges are identified as:

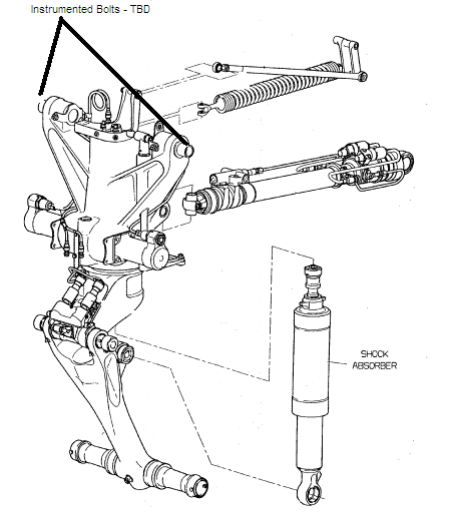
- Supplying safety critical loads (EMAs that govern the aircraft control surfaces) with 270Vdc introduce a new challenge in aeronautical applications. The maximum power of the system is 40kW aprox.
- Definition of algorithms for Distribution Systems including reconfigurations (according with loads safety requirements).
- Integration of 270V DC safety critical system into an electrical system based in other voltages (115V AC, 28V DC). A specific CfP will be launched to extend technology of Clean Sky in a Power Converter Unit from 115 Vac to 270 Vdc.
- One important research in this CfCP is to consider new switching technologies devices materials based on carbide silicon (SiC) because of their promising applications in high power, high temperature applications.
- Intelligent electrical energy management must be tested in flight conditions, with real loads demanding of real flight actuators.
- Integration of all specific HVDC protection systems (against arc fault, Partial discharge, etc...). Testing of protection systems in flight conditions.
- Advance modelling and simulation methods to prevent integration problems and support the permit to flight, obtaining processes to anticipate problems in later integration phases.

LANDING GEAR

The landing gear technology lines are devoted to optimize landing gear structure within airframe structure and aircraft loads reduction on ground. A proper design of these technologies may have important benefits in wing structural weight due to loads reduction at landing and taxi. The focus of these activities will be research in loads measurements by means of specific devices included in the landing gear (SHMS sensors) and technologies applied to the shock absorber which may reduce loads acting on physical properties of the hydraulic fluid.

These technologies will be applied to the landing gear of the Regional Aircraft FTB2, with shock absorber reference characteristics:

Overall length compressed	580 mm
Overall length extended	700 mm
Stroke	120 mm
Inflation gas	Dry nitrogen
Inflation pressure	1.6 MPa
Estimated weight Less than	12 kg
Max. shock absorber force	500 KN.



The objective of the first technology line, the **Semi active Shock Absorption based in magnetorheological fluids**, is to control the shock absorber force by changing the viscosity of the hydraulic fluid. The viscosity of these fluids is controlled through an application of a magnetic field.

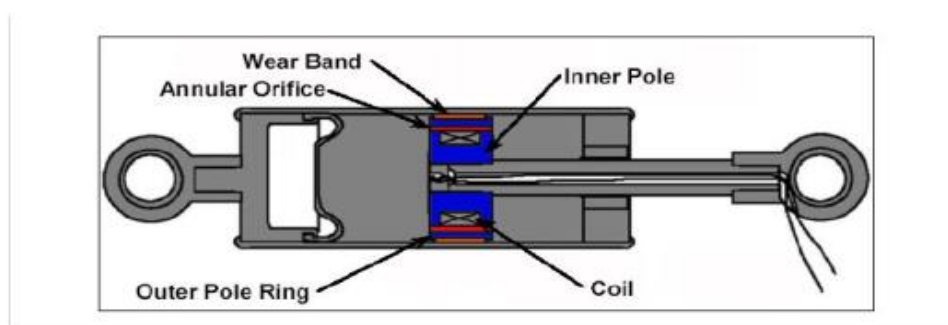


Figure 6. Magnetorheological (MR) shock absorber

The shock absorber solution consists of a conventional oleo-pneumatic configuration in which the

hydraulic restrictor is replaced by a magnethoreological valve. The mission of the valve is to control the damping force. An electrical signal will activate this valve that will produce the magnetic field required to achieve the needed damping force. The three steps in this technology line are:

- Electric valve prototype for flow and fluids characterization.
- Shock Absorber prototype for damping characteristics evaluation (including electric valve).
- Control units for open and closed loops (HW and SW).

The CP will be in charge of a prototype of shock absorber working under magnethoreological principles. These device needs to reach a TRL 5 of on-ground tests showing the expected behaviour of the system and specific tests in CP installations will be designed for this purpose.

The main objective of the landing gear loads monitoring is a reliable system to measure loads during the ground manoeuvres of the aircraft (shms sensors). In this case innovative calibrated bolts are the proposed technology and ground (trl 5) and in-flight (trl 6) tests in the ftb2 demonstrator are the target of this line. Secondly, to discriminate the loads to be measured according to:

- Complete ground loads for fatigue monitoring
- Static loads for aircraft weighting
- Landing loads for hard landing detection

And finally, to design a system to process loads for every application (fatigue loads, weight or hard landing) with these technological solutions:

- Some an instrumented LG bolts with a reliable and accurate instrumentation.
- An acquisition system (HW and SW) to process the signal.

ICE PROTECTION

The objective is to improve energy consumption and effectiveness of current ice protection system technologies by using electrical induction heating and two-phase heat transport devices. The ice protection systems will be embedded in carbon fiber structures prepared by the WAL or other Core-Partners in close relationship with components of the Regional Aircraft IADP.

For the induction electrical heating, the solution consist of an array of induction coils integrated below a CFRP laminate providing the adequate heating energy either in de-icing or anti-icing mode. The array will be controlled and energy supplied from a controller. Disposition and number of the coils is one of the critical aspects in order to obtain the proper heating power density.

For the two-phase heating, the solution will consist of a group of heat transport lines integrated in a metallic ice accreting surface providing the adequate energy for ice protection. The heat source will be inside the Powerplant installation with maximum temperature of the heat source reaching continuously 250 deg C.

The target of this technology line is to achieve TRL 4, therefore tests will be performed in on-ground facilities checking concepts feasibility and functional aspects. Typical environmental tests (temperature, vibrations, ...) will be done and also ice – wind tunnel tests to show systems performance to de-ice carbon fiber surfaces in simulating flight conditions.

3. Special skills, certification or equipment expected from the Applicant

The Applicant shall have the following:

- Demonstrated experience (based on history) in design and manufacturing of airborne equipment qualified under RTCA-DO-160, RTCA-DO-178, and RTCA-DO-254 for critical equipment or other civil or military equivalent standards.
- Experience in equipment showing compliance with Electrical Power Normative MIL-STD-704F power quality.
- Demonstrated knowledge and experience in the technologies in this CFCP (especially relevant for magneto-rheological).
- Capacity to assembly and testing complex aeronautical equipment.
- Design and analysis tools of the aeronautical industry
- Competence in management of complex projects of research and manufacturing technologies.
- Experience in integration multidisciplinary teams in concurring engineering within reference aeronautical companies.
- Proven experience in collaborating with reference aeronautical companies, industrial partners, technology centers within last decades in:
 - o Research and Technology programs (TRL Reviews)
 - o Industrial air vehicle with “in – flight” components experience.
- Capacity to support documentation and means of compliance to achieve prototype “Permit to Fly” with Airworthiness Authorities (FAA, EASA...).
- Capacity to specify components and systems tests along the design and manufacturing phases of aeronautical equipments, including:
 - o Characterization of innovative materials
 - o Equipment type tests (vibration, temperature humidity, etc)
 - o Advanced instrumentation systems
 - o Impact tests (i.e. low energy tests)
- Capacity to provide support to system functional tests of large aeronautical equipment: Tests definition and preparation and Analysis of test results. Especially relevant (but not only) for drop test for landing gears.
- Capacity to repair “in-shop” equipment due to manufacturing deviations.
- Capacity to support to Air vehicle Configuration Control.
- Product Organization Approvals (POA)
- Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004)
- Qualification as Material and Ground Testing Laboratory of reference aeronautical companies (i.e. ISO 17025 and Nadcap).
- Capacity of performing Life Cycle Analysis (LCA) and Life Cycle Cost Analysis (LCCA) of materials and structures, and systems.
- Capacity of evaluating results in accordance to Horizon 2020 environmental and productivity goals following Clean Sky 2 Technology Evaluator rules and procedures.

- Capacity of evaluating design solutions and results along the project with respect IAW Eco-design rules and requirements
- Experience with mechanical (relevant for shock absorber damping characteristics), electrical, electromagnetic (relevant for induction) and thermodynamic (relevant for two phase) and modeling and simulation tools (SABER, Matlab/Simulink, AMESim).

In addition, particularly for the Ka antenna:

- Capacity to support documentation and means of compliance to achieve a prototype under the International Telecommunications Union (ITU) to radiate in the Ka band within the limits of power flux density, frequencies and interoperability.
- Capacity to establish a satellite radiolink to carry out the ground and flight test.
- Experience in technological research in the following fields:
 - High data rate satellite radiolink based on electronically steering antennas.
 - Radio frequency modules to distribute and mix the base band signals.
 - Highly integrated structures.
- Capacity to provide support to structural and functional tests of complex antenna system:
- Certified facilities for the antenna measurement.

Simulation tool for analytical calculations: antenna design and coverage calculation

4. Major deliverables and schedule

In general, the list of deliverables in all projects is as follows:

Ref. No.	Title - Description	Type
D-1	State of Art	Report
D-2	Trade-offs	Report
D-3	Technical Documentation Supporting PDR	Reports
D-4	Technical Documentation Supporting CDR	Reports
D-5	Simulation Models - Associated documentation	Models reports
D-6	Delivery parts - Associated documentation	Equipments reports
D-7	Technical Documentation supporting Validation Process "on ground"	Measurements Reports
D-8	Technical Documentation supporting Validation Process "In flight"	Measurements Reports
D-9	Exploitation and dissemination	Summarize Report

The applicant(s) shall detail the documents proposed for each of the projects.

The schedule for each projects and main milestones are indicated in following picture

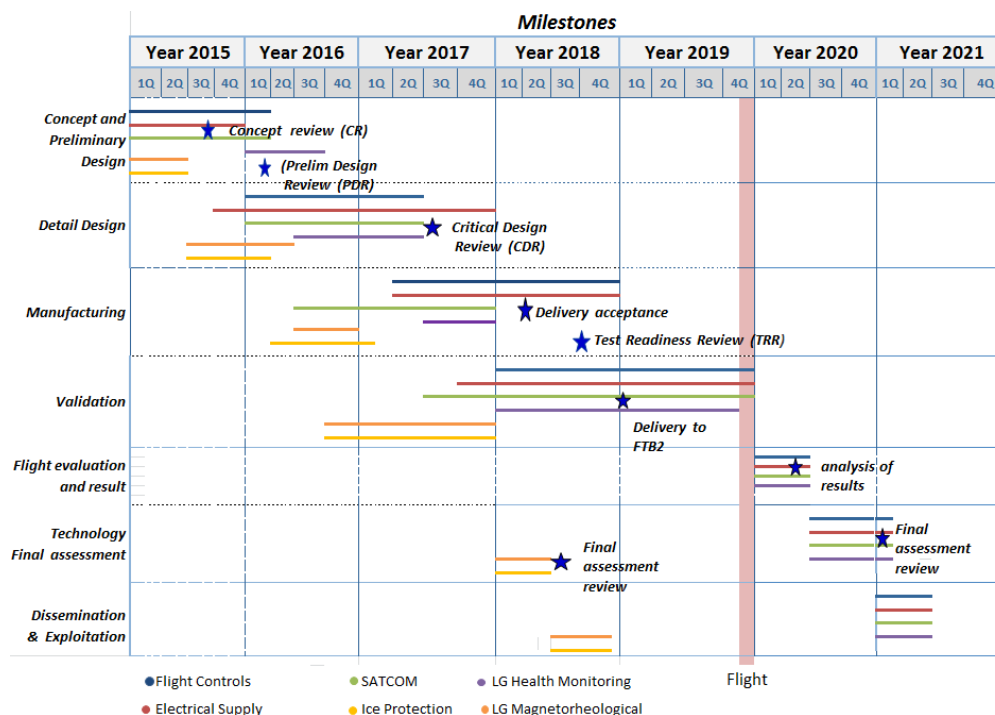


Figure 7. Schedule and Milestones

5. Definition of terms

AC	Alternating Current	JTP	Joint Technical Programme
A/C	AirCraft	KANDU	KA band Network Data Unit
ACE	Associated Control Electronic	KRFU	KA Radio Frequency unit
CP	Core-Partner(s)	LCA	Life Cycle Analysis
CASA	Construcciones Aeronáuticas Sociedad Anónima	LCCA	Life Cycle Cost Analysis
CDR	Critical Design Review	LG	Landing Gear
CfCP	Call for Core-Partner(s)	MLA	Manoeuver Load Alleviation
CfP	Call for Proposal	MOSFET	Metal Oxide semiconductor Field Effect Transistor
CFRP	Carbon Fiber Reinforced Plastic	MR	Magneto Rheological
CG	Centre of Gravity	MRF	Magneto Rheological Fluid
CTD	Capability and Technology Domain	MRV	Magneto Rheological Valve
DC	Direct Current	NLG	Nose Landing Gear
EADS	European Aerospace and Defense Company	PDR	Preliminary Design Review
EASA	European Aviation Safety Agency	PFACE	Primary Flight Actuator Control Electronic
ECU	Electronic Control Unit	POA	Production Organization Approval
EMA	Electro Mechanical Actuator	RF	Radio Frequency
EMI	Electro Magnetic Interference	RTCA	Radio Technical Commissioning for Aeronautics
EPDS	Electric Power Distribution System	S/A	Shock Absorber
ESVA	Electro hydraulic SerVo Actuator	SATCOM	SATellite COMMunications
FDR	Flight Data Recorder	SiC	Silicon Carbide
FTB2	Flight Test Bed 2	SHMS	Structural Health Monitoring System
FTI	Flight Test Instrumentation	SPD	System Platform Demonstrator
GaN	Gallium Nitride	SSPC	Solid State Power Controller
GLA	Ground Load Alleviation	TBC	To Be Confirmed
GRA	Green Regional Aircraft	TBD	To Be Defined
HVDC	High Voltage Direct Current	TRL	Technology Readiness Level
ISO	International Standard Organization	WAL	Work Area Leader
ITU	International Telecommunications Union	WBS	Work Breakdown Structure
ITD	Integrated Technology Demonstrator	WFF	Wing to Fuselage Fairing
IADP	Innovative Aircraft Demonstrator Platform	WP	Work Package

IV. Out of Autoclave Composite Manufacturing, Wing and Tail Unit Components and Multifunctional Design

Leader and Programme Area [SPD]	AIR		
Work Packages (to which it refers in the JTP)	B.1.3 / B.1.4 / B.2.3 / B.4.1		
Indicative Topic Funding Value	7,5 M€		
Leading Company	EADS-CASA		
Duration of the action	7 years	Start Date	01/01/2015
Date of Issue	01/06/2014	Call Wave	1

Topic Number	Title		
JTI-CS2-2014-CPW01-AIR-02-02	Out of Autoclave Composite Manufacturing, Wing and Tail Unit Components and Multifunctional Design	Duration	7 years
		Start Date	01/01/2015

Short description

The aim of this Call for Core-Partner(s) is to design and manufacture aeronautical components for Clean Sky 2 “on-ground” and “in-flight” demonstrators: Regional Aircraft FTB2 and LifeRCraft. These components will include the state of the art in composite manufacturing (i.e. out of autoclave processes), innovative materials (i.e. thermoplastics) and adaption of structural architectures to host highly integrated systems.

The Regional Aircraft FTB2 components and main technological challenges are:

- Outer External Wing – Upper Skin: innovative materials and manufacturing process
- Winglet: morphing design to improve a/c performance
- Out-Board Flap: new design to improve a/c performance
- External Wing Leading Edge: morphing design to improve a/c performance
- Outer External Wing – Ribs: innovative materials and manufacturing process

The LifeRCraft components and main technological challenges are:

- Tail Boom: innovative materials, manufacturing process and light weight structures.
- HTP: innovative manufacturing process and design to improve R/C performance and light weight structures
- VTP: innovative manufacturing process and design to improve R/C performance and light weight structures
- Surface Control: innovative manufacturing process and design

Components ready-for-flight will be integrated in the air vehicles with the objective of bringing Technologies to Full Scale Flight Demonstrators levels (Full TRL 6).

This Call for Core-Partner(s) belongs to the Airframe ITD, and herein to the Activity Line High Versatility and Cost Efficiency (HVCE).

1. Background

This Call for Core-Partner(s) deals with the state of the art in technologies developed within last years related to design and manufacturing processes focus on automated production, innovative materials like thermoplastics and aeronautical structural integration to host complex systems.

The current Call for Core-Partner(s) is allocated into the frame of Clean Sky 2 where several demonstrators will be developed by the industry, named Innovative Aircraft Demonstrator Platforms (IADP). The tasks within this project involve components for two of them: the **Regional Aircraft FTB2** leaded by **EADS-CASA** and the **LifeRCraft** leaded by **AIRBUS HELICOPTERS**.

The project proposed will deal with technologies within the **Airframe ITD** applicable to **Regional Aircraft and Fast Rotorcraft IADPs**. The activities required in this Call are linked to the following Technology Streamlines of the Airframe ITD:

- Next Generation Optimized Wing Box (WP B.1.3 and WP B.1.4)
- Optimized High Lift Configurations (WP B.2.3)
- Rotorless tail for Fast Rotorcraft (WP B.4.1)

2. Scope of work

▪ INTRODUCTION

In the framework of Clean Sky 2 programme EADS-CASA is leading the Airframe ITD and also participate in the Regional Aircraft IADP. Analogously, Airbus Helicopters is also involved in the Airframe ITD and is co-leader in the Fast Rotorcraft IADP. The objective of most of the technologies involved in the Airframe ITD are to reach a maturity level to be tested “in-flight” in the Regional Aircraft FTB2 and the LifeRCraft demonstrators.

The Regional Aircraft FTB2 is a prototype aircraft based on the EADS – CASA C295 model. This aircraft is Civil FAR 25 certified by FAA and EASA Airworthiness Regulations with large in-service experience as regional aircraft which is a very suitable platform to test in flight Clean Sky 2 mature technologies.

The LifeRCraft is a prototype air vehicle based on the architecture described in the Patent FR07-03615 with high-mounted wings which accommodate the transmission shafts driving two tip propellers. It features an airplane-like tail. No tail rotor is needed as the differential propeller pitch ensures main rotor torque balance and aircraft yaw control in hover and low speed.

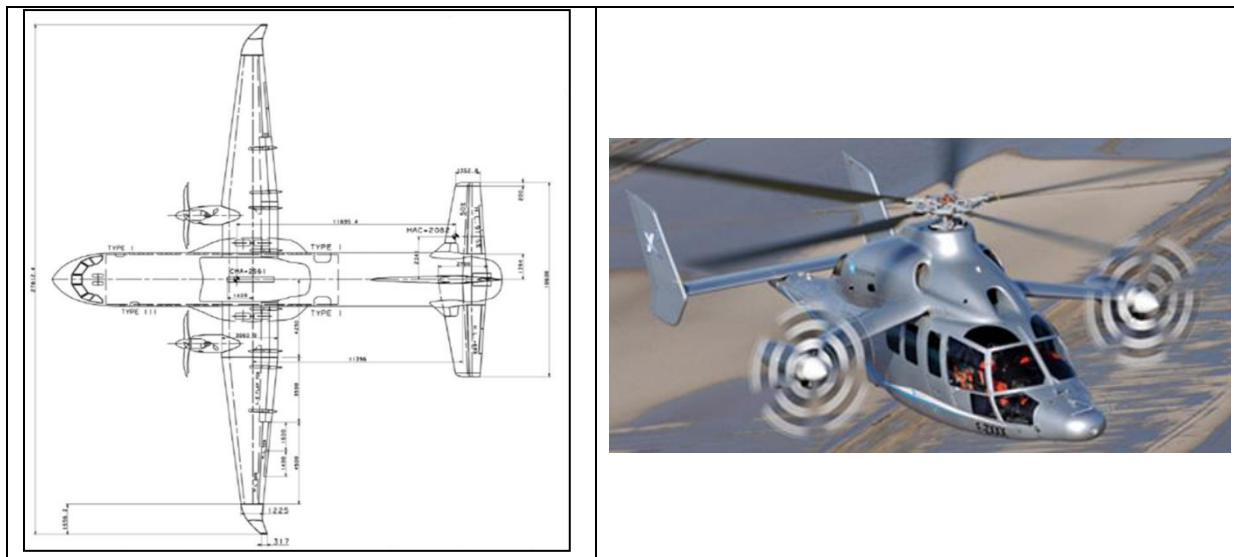


Figure 1. Regional Aircraft FTB2: EADS-CASA C295 –left-. Fast Rotorcraft LifeRCraft: X3 AIRBUS HELICOPTER –right-

The structural components required within the framework of this Call for Core-Partner(s) belong to the wing of the Regional Aircraft FTB2, of reference length 13 m, and the tail unit of the LifeRCraft air vehicle, with 5 m reference length (TBC). The main components are shown in Figure 2.

The dimensions and drawings shown in this call for the regional A/C components are for information only. The final aero shapes and concepts for flaps, winglets, etc. will be fixed during the first phase of the CS2 project in coordination with the activities in the Regional A/C IADP, led by EADS-CASA.

Some components will be entirely designed within the context of Clean Sky 2 to show technology achievements, some will be partially modified due to structural or systems interfaces and some remain from the basis air vehicles. The components to be manufactured within the scope of this Call are summarized in Tables 1 and 2.

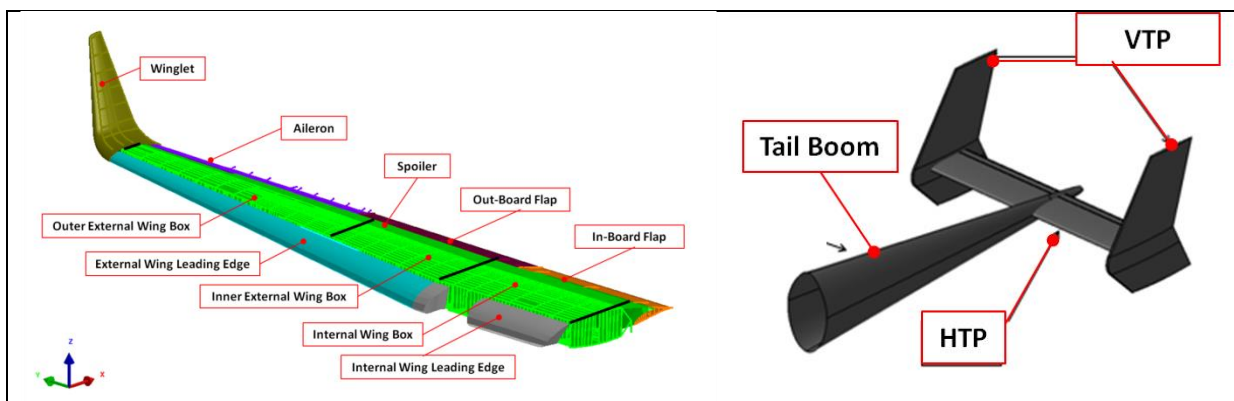


Figure 2. Structural components of the Regional Aircraft FTB2 wing –upper-& the LifeRCraft tail unit

COMPONENT	TECHNOLOGY CHALLENGES	TECHNOLOGY DEMONSTRATORS
OUTER EXTERNAL WING – UPPER SKIN	Innovative materials and manufacturing processes: - Composite materials with thermoplastic resin - In-situ Co-consolidation process with no-welding - Out of Autoclave curing process Improvements in reparability based on thermal processes Production time reduction Energetic and environmental costs reduction	• 1 specimen for “on – ground” static and functional tests • 2 specimens (both wings) ready for flight
WINGLET	Morphing structure: design trade-off between active or passive concepts Aircraft performance: multi-point drag optimization Active loads alleviation (MLA and GLA) High integrated structure / systems (EMAs) Innovative materials and manufacturing processes: - Composite materials - Reduction of Out of Autoclave cycle processes	• 1 specimen for “on – ground” static and functional tests • 2 specimens (both wings) ready for flight
OUT-BOARD FLAP	Aircraft performance in landing and take-off configurations Design trade-off Structural architecture to host highly integrated systems - Continuous deployment - Drag reduction	• 1 specimen for “on – ground” static and functional tests • 2 specimens (both wings) ready for flight
LEADING EDGE EXTERNAL WING	Aircraft performance in landing and take-off configurations Morphing actuation system De-icing system Innovative materials and manufacturing processes: - Composite materials with thermoplastic resin - In-situ Co-consolidation process with no-welding - Out of Autoclave curing process Improvements in reparability based on thermal processes Production time reduction Energetic and environmental costs reduction	• 2 specimens for “on – ground” static and functional tests

COMPONENT	TECHNOLOGY CHALLENGES	TECHNOLOGY DEMONSTRATORS
OUTER EXTERNAL WING – RIBS	Innovative materials and manufacturing processes: - Light metallic alloys with enhanced characteristics (strength, fatigue) - Super-plastic forming, Additive Layer Manufacturing, ... - Inspection of shape control (spring-back) Weight optimization in hybrid structures: - Metallic parts: ribs - Composite parts: spars and skins - Enhanced shimming processes	• 1 specimen kit for “on – ground” static and functional tests • 2 specimen kits (both wings) ready for flight

Table 1. Wing structural components manufactured by the Core-Partner(s)

COMPONENT	TECHNOLOGY CHALLENGES	TECHNOLOGY DEMONSTRATORS
TAIL BOOM	Weight target 31 kg Possible innovative manufacturing processes • Infusion / Pre-preg • Full Barrel laminating • Isogrid structures • Stitching • Co-curing Reduction of production time, single parts and part fixations Energetic and environmental costs reduction	• 1 specimen kit for “on – ground” static and functional tests • 1 specimen kit ready for flight
HTP	Weight target 24 kg –fully equipped- Highly integrated structure & systems De-icing integration Possible innovative materials and manufacturing processes • One Shot RTM • Fitting Integration • High module plastics Reduction of production time, single parts and part fixations Energetic and environmental costs reduction	• 1 specimen kit ready for flight
VTPs	Highly integrated structure & systems De-icing integration Possible innovative manufacturing processes	• 2 (TBC**) specimen kit s ready for flight ** Different design for each

COMPONENT	TECHNOLOGY CHALLENGES	TECHNOLOGY DEMONSTRATORS
	- One Shot RTM - Fitting Integration Reduction of production time, single parts and part fixations Energetic and environmental costs reduction	kit
CONTROL SURFACES	Possible innovative manufacturing processes - One shot RTM - Fitting Integration Reduction of production time, single parts and part fixations Energetic and environmental costs reduction	2 (TBC**) specimen kits (both HTP and VTP) ready for flight ** Different design for each kit
Upper T/B Fairing (TBC)	Weight reduction Resistance to high in-service temperatures Possible innovative materials and manufacturing processes - Out-of-Autoclave - High module thermoplastics Reduction of production time, single parts and part fixations Energetic and environmental costs reduction	1(TBC) specimen kit ready for flight

Table 2. Tail Unit structural components manufactured by the Core-Partner(s)

The CP will closely work with the WAL and other Partners from the conceptual design of the components, design requirements, material selection, manufacturing processes and final specimen deliveries for structural and functional tests “on-ground” and “in-flight”. In addition, the CP is requested to manage CfP in agreement with the WAL to achieve the final aim of this Call.

In general, the conceptual design of every component will be driven by the WAL while the detailed design; manufacturing and partial assembly (when apply) will be done by the CP. A high level of concurrent engineering is required all along the project to coordinate design phases, manufacturing, system integration and assembly in “on – ground” and “in – flight” demonstrators. The WALs (EADS-CASA and AHE) will require Airworthiness Authorities a Permit to Fly for the Regional Aircraft FTB2 and LifeRCraft with all technologies matured in the Clean Sky 2 and the CP will support this process, being mandatory for that the following activities:

- Providing material data, processes and tools accepted to achieve a Permit to Flight
- Harmonization of calculation processes/tools
- Materials used for primary structural elements must have the qualification level necessary to achieve a Permit to Flight (at the date of)
- Acting interactive with AH at any state of work

- Additionally to that the applicant(s) to this Call has to provide in its offer an estimated maximum weight of its proposed component. This value will be updated for the signature of the consortium agreement taking into account of the design data available at this time, the difference with the weight provided with the offer will be substantiated and the new weight figure will have to be agreed with the leader

The CP will provide the achievements with respect to Horizon 2020 and ECO-design objectives along the program. The results of the works need to be evaluated in terms of environmental and productivity objectives aligned with Clean Sky 2 strategy (CO₂ and NO_x emission reductions, fuel consumption efficiency and noise footprint impact) versus the current existing ones technologies. These studies will be assessed during all the project duration into the different QGs that will be performed. A special report focus on this aim will be performed by the WAL and CP. Weight saving vs improved functionalities will be monitored as most significant design drivers.

The dissemination of reports, technical documentation (e.g. substantiation documentation, test results, quality documentation, etc.), including information for Eco-design. AH/AHE is the responsible in front of the airworthiness agency for the flight permit, and it is required from the CP to provide to AH/AHE the necessary information and report within its responsibility perimeter to get flight permit.

a. OUTER EXTERNAL WING – UPPER SKIN

▪ Component General Description

The component is a stiffed skin of reference dimensions 800 x 4000 mm. The design will be performed in thermoplastic materials using In-Situ Co-consolidation (ISC) with no-welding and OoA technologies. The skin and stringers will be integrated in a single part using innovative processes at main structural component scale. Design and sizing of the component will be provided by the WAL, meanwhile manufacturing, quality assurance, low level tests and parts integration are responsibilities of the CP.

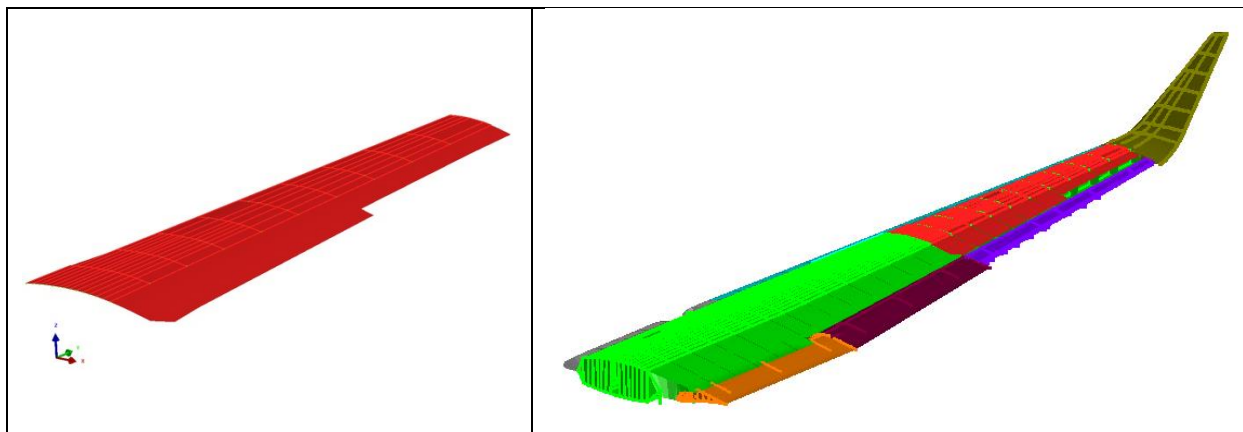


Figure 3. Outer External Wing – Upper Skin: component –left-, assembled in wing –right-

Materials and quality of the processes must be assured to support the final assembly in the

demonstrator for a flight test campaign in the Regional Aircraft FTB2. Thus, material characterization (minimum material database for design) and subcomponent structural tests need to be done and documented to ensure the robustness of the design. Lightning protection must be substantiated

▪ Technology Challenges

The Outer External Wing – Upper Skin has been selected as a representative component to show technology maturity regarding composite material with thermoplastic resins using In-Situ Co-consolidation (ISC) with no-welding and OoA manufacturing processes applicable to large size primary structures. Proposed materials to manufacture the parts are thermoplastic polymers with compatible carbon fibers like PEEK resin. Trade – off with other alternatives like PEKK, PPS, PAEK and others blends may be accepted based on WAL agreement. Thermoplastic materials improve reparability of the component based only on thermal processes, production time and reduction of energetic and environmental costs.

The preferred manufacturing processes need to be aligned with the absence of autoclave solutions as:

- In-situ co-consolidation of thermoplastic materials: one step processes without the participation of autoclave
- Thermoforming processes to ensure geometrical requirements of the part
- Roll – forming processes for stringer manufacturing in thermoplastic materials
- Co-consolidation procedures for stringers and skin integration
- Non Destructive Inspection (NDI) techniques compatible with manufacturing processes for validation of the structural integrity dimensions and shape control.
- Test for material characterization (allowable for design) and panel type tests (i.e. compression, shear, combined load). Minimum database for design.

The CP must explain its proposals for material and processes and also perform a risk – and mitigation analysis which include back-up technologies in case the selected ones could not reach initial expectations.

▪ Activities

1. Conceptual / Preliminary Design of component (WAL)
2. Material selection:
 - a. Mechanical properties characterization: coupons (CP)
 - b. Low level tests (i.e. mechanical, lightning) (CP in accordance with WAL)
3. Manufacturing process maturity (CP).
4. Detail Design and Analysis of component in accordance with manufacturing process maturity.
 - a. Dimensioning and structural analysis of the structure (WAL).
 - b. CATIA models and detail drawings, including systems provisions (WAL)
5. Tooling design and manufacture (CP).

6. Manufacturing plan and full process (CP)
7. Production of the full scale specimen for structural tests. "In-shop" repairs if needed (CP).
8. Non Destructive Inspection (NDI) for structural integrity, dimensions and shape control (CP).
9. Support to wing structural and functional test:
 - a. Test preparation (WAL with support from CP)
 - b. Test analysis (WAL with support from CP)
10. Production of specimens ready for flight to be assembled in the aircraft. "In-shop" repairs if needed (CP).
11. Non Destructive Inspection (NDI) for structural integrity, dimensions and shape control (CP).
12. Component documentation and support to Permit to Fly process (CP).
13. Evaluation of Horizon 2020 environmental and productivity objectives at component level (CP).

(*) Activity responsible in parenthesis (WAL: Work Area Leader, CP: Core-Partner(s))

b. WINGLET

▪ Component General Description

The component is a winglet of reference dimensions 1300 x 1500 x 1500 mm. The design will be performed preferably in composite materials using OoA technologies. Skins, ribs, spars, leading edge and trailing edge will be sub-assembled with maximum level of integration and reducing assembling work. The attachments of the winglet to the wing will be also included in the Call scope.

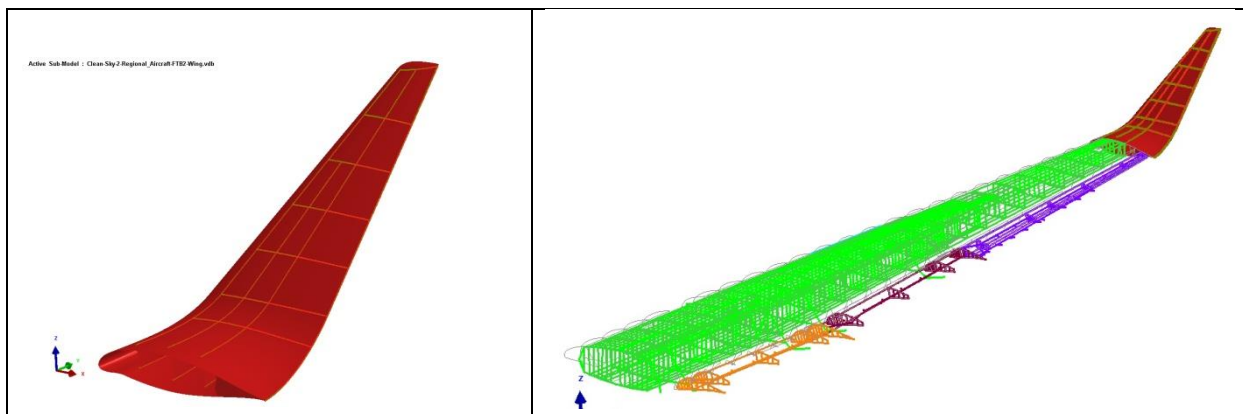


Figure 4. Winglet: component -left-, assembled in wing -right-

Conceptual design of the component will be provided by the WAL, meanwhile detail design, sizing, parts manufacturing, quality assurance and low level tests are responsibilities of the CP. Design requirements will be fixed by the WAL (external aero shape, installations, weight, stiffness ...)

Lightening protection must be substantiated

▪ Technology Challenges

Following the main goal to obtain a structure suitable of being optimized in multiples flight segments contributing effectively to the flight MLA, the Winglet has been selected as a representative component to show technology maturity regarding morphing and composite material and OoA manufacturing processes applicable to geometric complex and highly integrated structures. Thus, the objective is to eliminate, as far as possible, the autoclave cycles during manufacturing.

The first activities of the WAL are to perform a structural trade – off between winglet concepts (laminar winglet, morphing trailing edge winglet, split – flap winglet and aero-elastic winglet). Among these alternatives, one winglet concept will be selected for manufacturing and the CP will start the detail design, structural sizing, material selection and manufacturing processes.

Proposed materials to manufacture the parts should be preferably composite suitable for OoA processes which are already certified or close to certification with enough characterization and testing background. The selection will be agreed with the WAL. OoA processes are good candidates for winglet manufacturing in conjunction with advanced No Destructive Inspection (NDI) techniques (i.e. LRI, RTM, SQRTM)

The CP must explain its proposals for material and processes and also perform a risk – and mitigation analysis which include back-up technologies in case the selected ones could not reach initial expectations.

▪ Activities

1. Structural trade-off of different winglet concepts in accordance with Conceptual design provided by the WAL: active and passive winglets (CP in accordance with WAL)
2. Preliminary Design of component considering general requirements established by the WAL: aero-shape, functionality, systems provisions in structural design, etc. (CP)
3. Material selection:
 - a. Mechanical properties characterization if needed: coupons (CP)
 - b. Low level tests (i.e. mechanical, lightning) (CP in accordance with WAL)
4. Manufacturing process maturity (CP). Fabrics patterns definition and pre-forming, injection, tooling and trials
5. Detail Design and Analysis of component in accordance with manufacturing process maturity, including winglet attachments to the wing.
 - a. Dimensioning and structural analysis of the structure (CP).
 - b. CATIA models and detail drawings, including systems provisions (CP)
6. Tooling design and manufacture (CP).
7. Manufacturing plan and full process (CP).
8. Production of the full scale specimen for structural tests. "In-shop" repairs if needed. COS in agreement with WAL. (CP)
9. Non Destructive Inspection (NDI) for structural integrity, dimensions and shape control (CP).
10. Support to wing structural and functional test: preparation and analysis (CP in cooperation with WAL)
11. Production of specimens ready for flight to be assembled in the aircraft. "In-shop" repairs if needed. COS in agreement with WAL. (CP).
12. Non Destructive Inspection (NDI) for structural integrity, dimensions and shape control (CP).
13. Component documentation and support to Permit to Fly process (CP).
14. Evaluation of Horizon 2020 environmental and productivity objectives at component level (CP).

(*) Activity responsible in parenthesis (WAL: Work Area Leader, CP: Core-Partner(s)).

c. OUT-BOARD FLAP

▪ Component General Description

The component is an out-board flap of reference dimensions 900 x 3500 mm with two flaps tracks for deployment and two actuator attachments. The aim of this component is to study a continuous deployment system to optimise climb and cruise performances. and high efficiency trailing edge tab to improve performances in take-off and landing configurations. Therefore, the driver of the design is ensuring a proper kinematic actuation for the desired aero-shape of the high lift surface.

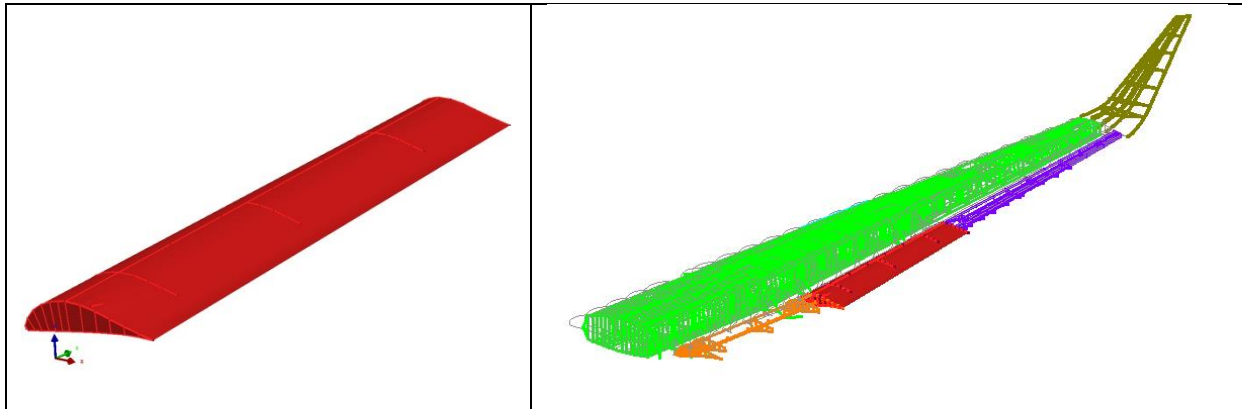


Figure 5. Out-Board Flap: component –left-, assembled in wing -right-

This is the baseline design on top of which several technology concepts will be studied and manufactured. The conceptual design of the component will be provided by the WAL, meanwhile detail design, sizing, parts manufacturing, quality assurance and low level tests are responsibilities of the CP. Design requirements will be fixed by the WAL (external aero shape, installations, weight, stiffness, deployment kinematics, definition of actuation systems ...)

Materials and quality of the processes must be assured to support the final assembly in the demonstrator for a flight test campaign in the Regional Aircraft FTB2.

▪ Technology Challenges

The technological concepts to be investigated are devoted to increase aerodynamic efficiency in take-off and landing configurations and noise reduction:

- Flap with continuous deployment (single or multiple vanes)
- Flap with Trailing Edge Tab
- Flap tracks and fairings with reduced drag
- Flap with Morphing Trailing Edge

Flap deployment kinematics and the actuation system will be fixed by the WAL and other Partners. Materials and quality of the processes must be assured to support the final assembly in the demonstrator for a flight test campaign in the Regional Aircraft FTB2. The Detailed Design of the flap will be responsibility of the CP.

▪ Activities

1. Structural trade-off of different flap concepts in accordance with Conceptual design provided by the WAL: deployment kinematics, deployment actuation system interfaces and trailing edge actuation (CP in accordance with WAL).

2. Preliminary Design of component considering general requirements established by the WAL: aero-shape, functionality, systems provisions in structural design, etc. (CP)
3. Material selection:
 - a. Mechanical properties characterization if needed: coupons (CP)
 - b. Low level tests (i.e. mechanical, lightning) (CP in accordance with WAL)
4. Manufacturing process maturity. (CP)
5. Detail Design and Analysis of component in accordance with manufacturing process maturity
 - a. Dimensioning and structural analysis of the structure (CP).
 - b. CATIA models and detail drawings, including systems provisions (CP)
6. Tooling design and manufacture (CP).
7. Manufacturing plan and full process (CP).
8. Production of the full scale specimen for structural and functional tests. "In-shop" repairs if needed. COS in agreement with WAL. (CP)
9. Non Destructive Inspection (NDI) for structural integrity, dimensions and shape control (CP).
10. Simplified structural and functional tests to ensure flap deployment: contactless surface metrology considering (CP):
11. Support to wing structural and functional test: preparation and analysis (CP in cooperation with WAL)
12. Production of specimens ready for flight to be assembled in the aircraft. COS in agreement with WAL. "In-shop" repairs if needed. (CP).
13. Non Destructive Inspection (NDI) for structural integrity, dimensions and shape control (CP).
14. Component documentation and support to Permit to Fly process (CP).
15. Evaluation of Horizon 2020 environmental and productivity objectives at component level (CP).

(*) Activity responsible in parenthesis (WAL: Work Area Leader, CP: Core-Partner(s)).

d. EXTERNAL WING LEADING EDGE

▪ **Component General Description**

The component is a section of the External Wing Leading Edge with reference dimensions 2000 x 400 mm. The elastic morphing will be obtained by means of an actuator and the deformed shape will improve aircraft performances in take-off and landing. The design will be performed in thermoplastic materials using In-Situ Co-consolidation (ISC) with no-welding and OoA technologies. Design and sizing of the component will be provided by the WAL, meanwhile manufacturing, quality assurance, low level tests and parts integration are responsibilities of the CP.

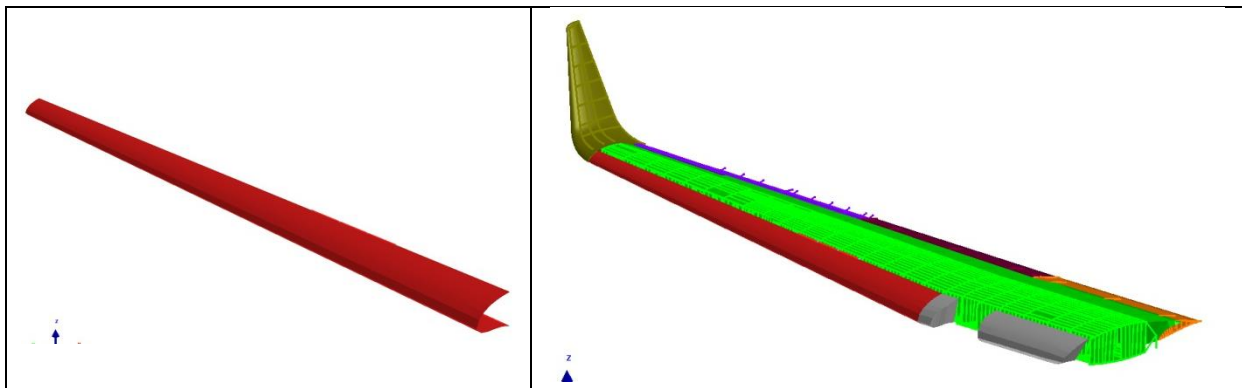


Figure 6. External Wing Leading Edge: component –left-, assembled in wing –right-

Materials and quality of the processes must be assured to support the final assembly in the “on-ground” demonstrators. Thus, material characterization (minimum material database for design) and subcomponent structural tests need to be done and documented to ensure the robustness of the design.

▪ Technology Challenges

The leading edge component will be used to install a morphing system for optimizing aerodynamic shapes and innovative de-icing systems based. Thermoplastic materials improve reparability of the component based only on thermal processes, production time and reduction of energetic and environmental costs.

The preferred manufacturing processes need to be aligned with the absence of autoclave solutions as: ISC of thermoplastic, thermoforming, roll – forming, co-consolidation, NDI, tests for material characterization (minimum database for design). Proposed materials to manufacture the parts are thermoplastic polymers with compatible carbon fibers like PEEK resin. Trade – off with other alternatives like PEKK, PPS, PAEK and others blends may be accepted, based on WAL agreement.

The CP must explain its proposals for material and processes and also perform a risk – and mitigation analysis which include back-up technologies in case the selected ones could not reach initial expectations.

▪ Activities

1. Conceptual / Preliminary Design of component (WAL).
2. Material selection:
 - a. Mechanical properties characterization coupons (CP)
 - b. Low level tests (i.e. mechanical, lightning) (CP in accordance with WAL)
3. Manufacturing process maturity (CP).
4. Detail Design and Analysis of component in accordance with manufacturing process

maturity.

- a. Dimensioning and structural analysis of the structure (WAL).
 - b. CATIA models and detail drawings, including systems provisions (WAL)
5. Tooling design and manufacture (CP).
6. Manufacturing plan and full process (CP).
7. Production of two full scale specimens for structural and functional tests. "In-shop" repairs if needed (CP).
8. Non Destructive Inspection (NDI) for structural integrity, dimensions and shape control (CP).
9. Simplified structural and functional tests to ensure morphing behavior: contactless surface metrology
10. Support to wing structural and functional test: preparation and analysis (CP in cooperation with WAL)
11. Component documentation (CP).
12. Evaluation of Horizon 2020 environmental and productivity objectives at component level (CP).

(*) Activity responsible in parenthesis (WAL: Work Area Leader, CP: Core-Partner(s)).

e. OUTER EXTERNAL WING – RIBS

▪ Component General Description

The component is a kit of metallic ribs for the Outer External Wing. The number of ribs required will be fixed in the design of the Outer External Wing subcomponent in agreement with the WAL. Current design has eleven ribs along span. Ribs will be attached to a new composite Outer External Wing. These ribs are taken as demonstrators of mature metallic technologies and advanced hybrid joints between composite and metallic parts.

The CP is required to propose innovative design in metallic processes (i.e. super-plastic forming, additive layer manufacturing (ALM) in 3D printers) using light metallic alloys of titanium or aluminium with improved properties of strength and fatigue. Systems to guarantee quality in manufacturing like spring – back control, shape control ... are welcome.

A reduced number of specimens should be selected to prove new technology process suitability. Rest can be made on "state of the art" technology as far as read across covering overall sizes and other design requirements have been covered.

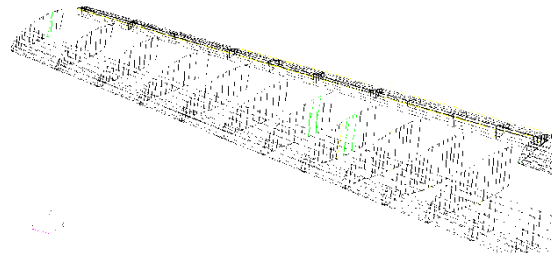


Figure 7. Ribs component –left-, assembled in wing -right-

■ Activities

1. Preliminary Design of component considering general requirements established by the WAL: aero-shape, functionality, systems provisions in structural design, etc. (CP in cooperation with WAL)
2. Material selection:
 - a. Mechanical properties characterization if needed: coupons (CP)
 - b. Low level tests (i.e. mechanical, lightning) (CP in accordance with WAL)
3. Manufacturing process maturity. (CP)
4. Detail Design and Analysis of component in accordance with manufacturing process maturity, including winglet attachments to the wing.
 - a. Dimensioning and structural analysis of the structure (CP).
 - b. CATIA models and detail drawings, including systems provisions (CP)
5. Tooling design and manufacture (CP).
6. Manufacturing plan and full process (CP).
7. Production of the full scale specimen for structural and functional tests. “In-shop” repairs if needed. COS in agreement with WAL. (CP)
8. Non Destructive Inspection (NDI) for structural integrity, dimensions and shape control (CP).
9. Support to wing structural and functional test: preparation and analysis (CP in cooperation with WAL)
10. Production of specimens ready for flight to be assembled in the aircraft. COS in agreement with WAL. “In-shop” repairs if needed. (CP).
11. Non Destructive Inspection (NDI) for structural integrity, dimensions and shape control (CP).
12. Component documentation and support to Permit to Fly process (CP).
13. Evaluation of Horizon 2020 environmental and productivity objectives at component level (CP).

(*) Activity responsible in parenthesis (WAL: Work Area Leader, CP: Core-Partner(s)).

f. TAIL UNIT

▪ **Component General Description**

Part of the subject of this call for Core-Partner(s) are all the activities needed for developing and manufacturing the Tail Unit of the LifeRCraft Demonstrator, therefore activities such as, technical assessments, design, manufacture and test will be necessary to perform into the scope of this call. Additionally to these Technical activities that will be described further as follows is also described the managing activities that as Core-Partner should be performed by it, always in accordance with the Strategic Topic Manager.

Scope of the Call and therefore of the works described in it, is a light weight tail unit for a fast rotorcraft (compound helicopter), developed and manufactured as much as possible, according ECO-design.

The Tail Unit comprises of the following main structural elements and all structural sub-elements belonging to it:

- Tail Boom
 - Reference dimensions 5000mm length and ϕ 1000mm in root
 - Tail Boom structure/ Mechanical interfaces to Centre Fuselage
 - Landing protection skid installation.
- Capability to withstand high temperatures-hot gases impact ($t > 190^{\circ}\text{C}$). HTP (Horizontal Tail Plane)
 - Reference dimensions 3500 x 800 mm
 - HTP Structure/ Mechanical interfaces to Tail Boom, VTP and actuators.
 - Capability of being dismountable.
- VTP (Vertical Tail Plane)-CP Responsibility
 - VTP Structure/ Mechanical interfaces to HTP and actuators.
 - Reference dimensions 2250 x 900mm

For the Tail Boom, HTP and VTPs should be taken into account the necessity of the following provisions for sub-systems (eg. flaps and flap-actuation system, harnesses, hydraulic system (if apply), antennas, fairings, lightning protection, static dischargers, position light, de-icing system implementation capability etc...) and for flight test instrumentation.

- Control Surfaces-CP Responsibility
 - Control Surfaces Structures/ Mechanical interfaces to HTP and VTP.
- Fairings and Doors-CP Responsibility
 - Tail Boom Fairing (TBC)
 - Maintenance doors

The Tail structure is a critical sub-system for rotorcraft flight handling quality, particularly the area

and the location of horizontal stabilizer. For this reason and to give the suitable flexibility for the demo development, the tail structure design shall include capabilities to fit and test the HTP at several locations and with different surfaces.

The architecture of the tail shown in the page 4 (figure 2) is preliminary and may change during the Pre-design phase.

The target is to obtain the lowest weight possible for the proposed component compliant with technical requirements and compatible with a serial aeronautical production.

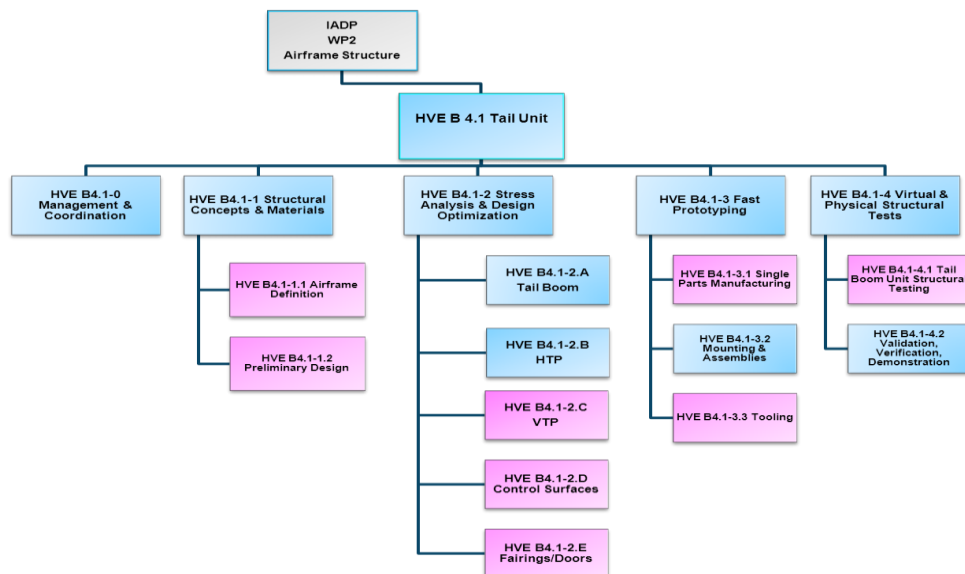
The applicant(s) shall provide in its offer an estimated maximum weight of its proposed component. This value will be updated at the signature of the consortium agreement taking into account the design data available at this time, the difference with the weight provided in the offer will be substantiated and submitted for approval of the leader.

▪ Activities

Following it will be detailed the expected works to be performed by the Core-Partner(s) for this project; always IAW the role and responsibilities expected for it from the WAL (Work Area Leader) AHE.

- Technical Activities: The Core-Partner RRs will be mainly as a Structural Design Responsible (SDR) for some TU major parts and Structural Manufacturing Responsible (SMR) for all the TU, therefore the tasks and the WPs in which completely or partially the CP will work are:
 - Technical Support for designing the Tail Unit, focus on Preliminary design. HVE B4.1-1.1 and HVE B4.1-1.2. for all the Tail Unit Single Parts. In the special case of the major parts under CP responsibility, detailed design and sizing shall also be done by the CP.
 - Manufacturing of all the Single Parts of the Tail Unit HVE B4.1-3.1.
 - Testing HVE B4.1-4.1
 - Manage the Weight and Recurring Cost assessment and evolution of each single parts of the TU.
- Management and Coordination Activities:
 - As Project Co-Leader, it will share the Responsibilities of this figure with the WAL (Airbus Helicopters España) for the overall project development.
 - Manage & Coordinate directly all the WPS that will be fully responsibility of the CP, always IAW WAL.
 - Launch, Manage and Coordinate all the CfP into the framework of the HVE B4.1 "Tail Unit for the LifeRCraft Demonstrator".

In order to provide a clear view of the tasks and works to be done by Core-Partner, it is enclosed the WBS for the HVE B4.1 Tail Unit for the LifeRCraft Demonstrator.



*In Blue are coloured all the work packages and sub-work packages fully responsible of AHE and in pink are all of them which are partly or fully responsible of the CP.

AHE will provide with enough information (interface definition, design loads documentation, general requirements specification...) prepared by AH and AHE with which it will enable the CP to master the tasks that are going to be described into this document. In addition, permanent support of AHE is envisaged.

In order to set AH into the position to achieve a permit to flight, several harmonisation tasks have to be done prior start of phase 1. This comprises

- Method and Tool harmonisation (substantiation, IT, Programme management)
- Quality assurance process harmonisation
- Communication management
- Content of substantiation file

HVE B4.1-1 Structural Concepts and Materials

Into this WP, it will be performed all the works from the conceptual design to the preliminary structural design, therefore this WP will finish once the QG identified as PDR will be successfully completed. During this phase, also it will be defined all the requirements for a high speed aircraft in ECO-design by designing an light weight and aerodynamically optimized structure in order to satisfy them.

The core-partner as SMR will support and perform together the WAL (AHE) the following tasks, always IAW the AHE Tail Unit concept:

- Design Trade-off Studies/Conceptual Studies.

- Support with the Structural Architecture and Structural Layout.
- Material and Production Trade-off Studies for Material and Production process selection.
- Interfaces Definition (Electrical, Hydraulic, etc...)
- Perform Preliminary Designs, Sizing and Documentation for Each Single Parts under responsibility of CP and Assemblies for PDR, including the ECO-design, weight and RC cost assessment reports.
- CI list.
- Test Plan Drafting
- CfP templates realization and manage all the CfP relatives to this WP (if apply).

HVE B4.1-2 Stress Analysis and Design Optimization

In this WP will be performed all the works that are between the preliminary structural design to the detailed structural design, therefore this WP will finish once the QG identified as CDR will be successfully complained.

This WP is subdivided into five sub-work packages.

The Tasks to be done by the CP will be (IAW AHE):

- Detailed Designs and Documents (included static and dynamic substantiation documents, if necessary) for each single parts and assemblies and test articles for CDR of which the CP will be fully responsible:
 - VTP
 - Control Surfaces
 - Fairings and Doors
- Final Detailed List of CIs for appropriate parts.
- Support to AHE to define means of Compliance for Technical Requirements.
- Support to Define the Test Components and Test Plan.
- Support to the AHE to perform a successful completion of each TRL Review.
- Update the reports about ECO-design, weight and RC assessment for each TU single parts focus on CDR (If an update of the overall weight is necessary, it will be submitted for approval of the leader)
- Perform the design modifications received from Production Phase after CDR completion.
- Manage the Interface with other IADP WPs.
- Perform and manage all the CfP relatives to this WP.
 - A CfP for performing the Detailed Design Documentation for Single Parts under CP responsibility. (TBC-if apply)

HVE B4.1-3 Fast Prototyping

All works included in this work package, include the manufacture of every single part, in addition to all the works associated to it (documentation and quality controls), the assembly of the tail unit and all test specimens and tooling manufacturing.

The WP has been divided in three sub-work packages:

1. Single Parts Manufacturing (HVE B4.1-3.1). WP fully responsible of the CP.
2. Mounting and Assembly (4.1-3.2). WP fully responsible AHE. In turn divided into:
 - M&A Testing Articles
 - M&A Demonstrator Articles

3. Tooling Manufacturing (4.1-3.3). WP fully responsible of the CP. In turn divided into:
 - Production Tooling
 - Assembly Tooling

The core-partner as SMR will perform the following tasks:

- Single Parts Manufacturing.
- Tooling (Single Parts Production and Assembly Tooling) Design and Manufacturing.
- Production Engineering tasks (Working Orders/Mounting Procedures/Conformity, etc....).
- Support to AHE with the Mounting/Assemblies /Functioning Trials (TBC).
- Perform the updating of the ECO-design, weight and RC assessments for TU single parts (Differences with CDR assessments has to be substantiated and explained to the WAL)
- Perform and manage all the CfP relatives to these sub-work packages.
 - A CfP for performing the Design and Manufacture of the Production Tooling (TBC).
 - A CfP for performing the Design and Manufacture of the Assembly Tooling (TBC).

HVE B4.1-4 Virtual and Physical Structural Tests

In this WP will be performed all the tasks from the Tail Unit Assembly completion, Test Campaign realization and the delivery of the Tail Unit, together with all the documentation required to receive Permit to Fly.

The CP will support and perform the following tasks:

- Ground Structural Test Campaign for ensuring and demonstrate the achieved level of safety:
 - Tail Boom Unit to Limit Load (TBC).
 - Test Coupons or Articles (TBD-TBC).
 - Calibration Test for Tail Unit (TBD-TBC).
- Prepare together with AHE the Documentation for obtaining the Demonstrator “Permit to Fly”.
- Support to AHE and AH, providing them a quick feedback and improvement in case of malfunctions, defects, improvements, damages for:
 - Tail Unit Assembly.
 - Tail Unit Delivery and Demonstrator Final Assembly.
 - Tail Unit into the Flight Tests Campaign.
- Support to the WAL with the Flight Test Campaign follow up.
- Perform the final updating after Flight Test Campaign of the ECO-design, weight and RC assessments for TU single parts (Differences with CDR assessments has to be substantiated and explained to the WAL)

3. Special skills, capabilities

- Experience in design and manufacturing of structures in non-conventional and conventional composite materials (thermoset and thermoplastic –regular and high temperature conditions-) and innovative metallic components (M)
- Capacity to assembly composite and metallic parts (aluminium, titanium ...); and hybrid joints (M)
- Design and analysis tools of the aeronautical industry (i.e. CATIA v5 r21, NASTRAN, VPM) (M)
- Competence in management of complex projects of research and manufacturing technologies (M)
- Experience with TRL Reviews in research and manufacturing projects for aero industry (M)
- Proved experience in collaborating with reference aeronautical companies with industrial air vehicle developments with “in – flight” components experience (M)
- Participation in international R&T projects cooperating with industrial partners, institutions, technology centres, universities and OEMs (Original Equipment Manufacturer) (A)
- Capacity of providing large aeronautical components within industrial quality standards (M)
- Capacity to support documentation and means of compliance to achieve experimental prototype “Permit to Fly” with Airworthiness Authorities (i.e. EASA, FAA and others which may apply) (M)
- Experience in technological research and development in the following fields (M):
 - Innovative processes in composite materials (i.e. thermoset, ISC thermoplastic, thermo-forming, In-Situ Co-consolidation with no-welding, Out of Autoclave technologies).
 - High Temperature Materials for Structural Applications.
 - Highly integrated structures (i.e. production rate, cost, and weight savings).
 - Assembly (when apply).
 - Process automation.
- Capacity to specify material and structural tests along the design and manufacturing phases of aeronautical components, including: material screening, panel type tests and instrumentation (A)
- Capacity to perform structural and functional tests of large aeronautical components: test preparation and analysis of results (M)
- Capacity to repair “in-shop” components due to manufacturing deviations (A)
- Capacity to support to Air vehicle Configuration Control (A)
- Capacity of performing Life Cycle Analysis (LCA) and Life Cycle Cost Analysis (LCCA) of materials and structures (A)
- Capacity of evaluating results in accordance to Horizon 2020 environmental and productivity goals following Clean Sky 2 Technology Evaluator rules and procedures (A)
- Capacity of evaluating design solutions and results along the project with respect Eco-Design rules and requirements (M)
- Design Organization Approval (DOA) (M)
- Product Organization Approvals (POA) (M)
- Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004) (M)
- Regulated facilities for the use of laser in manufacturing process (A)

- Qualification as Material and Ground Testing Laboratory of reference aeronautical companies (i.e. ISO 17025 and Nadcap) (M)
- Qualification as strategic supplier of structural test on aeronautical elements (A)
- Technologies for composite manufacturing with OoA processes: RTM, Infusion, SQRTM, In-Situ Co-consolidation, Thermoforming, Roll-forming (M)
- Metallic manufacturing, including Additive Layer Manufacturing (M)
- Mechanical processes, in both composite material and metallic. Hybrid joints (CFRP + Metal) (M)
- Automatic Thermoplastic laying and In-situ Co-Consolidation equipment (M)
- Automated manufacturing process (i.e. Automated Fiber Placement, Automated Tape Lay-up, Dry Fibre pre-forming) (M)
- Automated Fiber Placement machine laying up to six meter length, able to cover 360° parts, lay up radius of less than 100 mm and using slit tape ensuring maximum coverage of conical parts (A)
- Manual composite manufacturing: hand lay-up (M)
- Assembly jigs and assembly process definition (A)
- Tooling design and manufacturing for composite components (M)
- Autoclaves and ovens (temperatures above 400 °C) as back-up solutions of composite components (parts of Ø2m and 6m) (M)
- Advanced Non Destructive Inspection (NDI) and large components inspection to support new processes in the frame of an experimental Permit to Fly objective (A):
 - Dimensional and shaping inspections
 - Morphology studies of materials
 - Ultrasonic inspection capabilities
 - Additional NDI will be welcomed i.e.: Infrared (IR) Thermography, Laser Shearography, Laser ultrasonic inspection, X – ray Computed Tomography (XCT), ...
- Contactless dimensional inspection systems - Simulation and Analysis of Tolerances and PKC/AKC/MKC (Product, Assembly and Manufacturing Key Characteristics) (A)
- Experience in management, coordination and development technological programs (A)

(M) – Mandatory; (A) - Appreciated

4. Major deliverables and schedule (estimate)

Deliverables and schedule according to Top Level Plans at the time of the Call preparation.

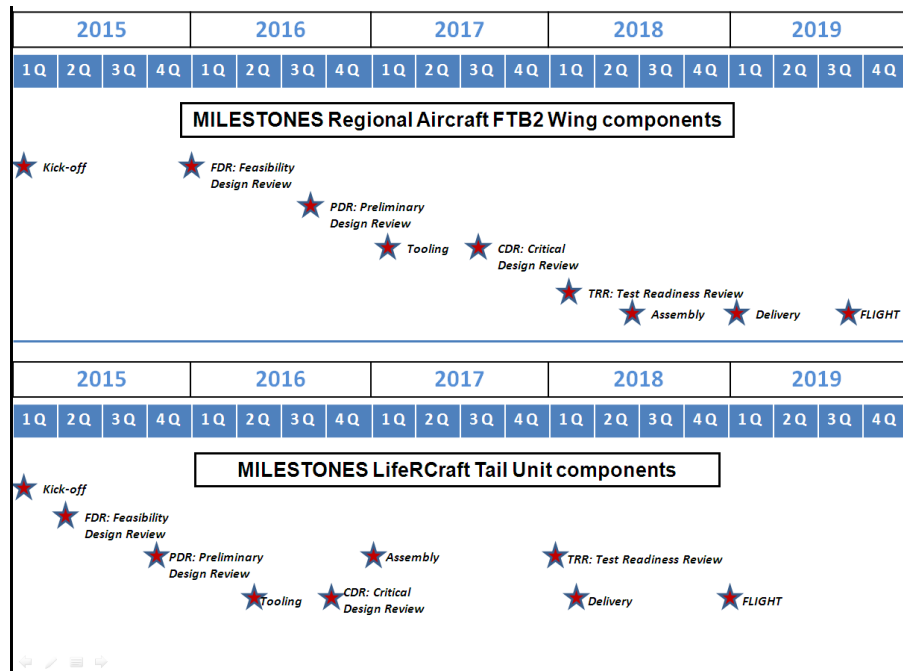
Deliverables			
Ref. No.	Title - Description	Type	Due Date
D.1.1	Structural trade-offs and Manufacturing Processes - Analysis of architectural trade – off - Proposed materials and manufacturing processes	Report	$T_0 + 12^*$
D2.1			$T_0 + 04^{**}$ $T_0 + 09^{**}$
D.1.2	Technical documentation supporting PDR - Structural Analysis - CATIA Models and drawings	Report Drawings	$T_0 + 18^*$
D2.2			$T_0 + 09^{**}$
D.1.3	Technical documentation supporting CDR - Structural Analysis - CATIA Models and drawings	Report Drawings	$T_0 + 30^*$
D2.3			$T_0 + 21^{**}$
D.1.4	Delivery of Parts and subassemblies for Full Scale Test (if apply) - Parts ready for final assembly in Tests specimens - Quality inspection reports	Parts Reports	$T_0 + 36^*$
D2.4			$T_0 + 26-31^{**}$
D.1.5	Delivery of Parts and subassemblies - Parts ready for final assembly in “in-flight” demonstrator - Quality inspection reports	Parts Reports	$T_0 + 39^*$
D2.5			$T_0 + 31^{**}$
D.1.6	Technical Documentation supporting Permit to Fly process with Airworthiness Authorities - Means of compliance	Reports	$T_0 + 50^*$
D2.6			$T_0 + 42^{**}$

* Applicable to Regional Aircraft wing components described in sections 1, 2, 3, 4 and 5

** Applicable to LifeRCraft Tail Unit components described in section 6

Topics for Core-Partners

Call 1



5. Definition of terms

TRL	Technology Readiness Level	M&A	Mounting and Assembly
OoA	Out of Autoclave	QG	Quality Gate
RTM	Resin Transfer Molding	R/C	Rotor Craft
SQRTM	Same Qualified RTM	RRs	Roles and Responsibilities
LRI	Liquid Resin Infusion	TBC	To Be Confirmed
IR	Infra Red	TBD	To Be Defined
XCT	X-ray Computerized Tomography	VTP	Vertical Tail Plane
POA	Production Organization Approval	WBS	Work Breakdown Structure
DOA	Design Organization Approval	WP	Work Package
EASA	European Aviation of Safety Agency	RH/LH	Right/Left Hand
FAA	Federal Aviation Administration	COS	Conditions of Supply
LCA/LCCA	Life Cycle (Cost) Analysis	SPC	Super Plastic Forming
OEM	Original Equipment Manufacturer	ALM	Additive Layer Manufacturing
R&T	Research and Technology	AHE	Airbus Helicopters España
GRA	Green Regional Aircraft	CfP	Call for Proposal
NDI	Non Destructive Inspection	CI	Configuration Items
MLA/GLA	Manoeuvre /Gust Loads Alleviation	EP	Eurocopter Procedure
EMA	Electro Mechanical Actuator	HTP	Horizontal Tail Plane
WAL	Work Area Leader	HVE	High Versatility and Cost Efficiency
CP	Core-Partner(s)	IAW	In Accordance With
ISC	In-Situ Co-consolidation	ITD	Integrated Technology Demonstrator
TU	Tail Unit	JTP	Joint Technical Proposal
SMR	Structural Manufacturing Responsible.	SDR	Structural Design Responsible.

V. Advanced Technologies for More Affordable Composite Fuselage

Leader and Programme Area [SPD]	AIR		
Work Packages (to which it refers in the JTP)	WP B-4.3		
Indicative Topic Funding Value	6,5 M€		
Leading Company	Alenia Aermacchi		
Duration of the action	7 Years	Start Date	01/04/2015
Date of Issue	09 July 2014	Call Wave	1

Topic Number	Title		
JTI-CS2-CPW1-AIR-02-03	Advanced Technologies for More Affordable Composite Fuselage	Duration	7 Years
		Start Date	01/04/2015

Short description and terms of reference

In the framework of the Airframe ITD the technological developments and demonstrations are structured around 2 major Activity Lines:

- Activity Line 1: Demonstration of airframe technologies focused towards “High Performance & Energy Efficiency” (HPE);
- Activity Line 2: Demonstration of airframe technologies focused toward “High Versatility and Cost Efficiency” (HVC).

Within the Activity Line 2, the Technology Stream B-4 “Advanced Fuselage” is included.

In particular, the Work Package B-4.3 “More Affordable Composite Fuselage” is incorporated within in the Technology Stream B-4.

In the framework of the WP B-4.3, the present Strategic Topic is addressed to the improvement of advanced technologies and methodologies coming from the Clean Sky - GRA ITD, FP7 MAAXIMUS, FP7 SARISTU with the aim to make them ready for the industrialization phase of a new regional aircraft fuselage.

All proposed methodologies and technologies shall be validated by following the building block approach from the coupon level up to fuselage sub-component level (real scale flat and curved panels) through element level (details representative of skin/stringers, fittings, aft. pressure bulkhead, window frames, floor structure). Methodologies and technologies so validated shall be applied to a real scale fuselage of a regional aircraft. The expected outcome of the present topic shall



Topics for Core-Partners Call 1



consist, in fact, in matured methodologies and technologies to be integrated in the full scale fuselage demonstrator within the Work Package 3.2 of Regional Aircraft IADP.

In the framework of the present Topic, activities to be performed by the Core-Partner(s) shall be included in the following 2 linked areas:

- 1) development of advanced methodologies and technologies for maintenance, repair, Non Destructive Inspection and Structural Health Monitoring;
- 2) fuselage components design, manufacturing and testing for verification and validation of new methodologies and technologies.

Within the 1st Area, methodologies for the operative costs estimation at the A/C fuselage level shall be developed. The goals are the maturation of reliable and cost efficient technologies for composites maintenance and repair with reduced complexity compared to state of the art solutions. Moreover the certification process shall be implemented through affordable testing procedures aimed to the Verification and Validation of the advanced composite fuselage including embedded dedicated sensors network.

The expected fields of investigations include: new design methodologies that incorporate advanced and up-scalable strategies for real time structural diagnosis and monitoring, maintenance procedures and repairing technologies.

Within the 2nd Area, 3 levels of items, from coupons to fuselage components, integrating new technologies shall be designed, manufactured including the sensors' integration, and tested, to validate the methodologies, by means of numerical / experimental correlations and to consolidate the TRL 6 at component level.

As novel verification and validation methods require millions of large scale computations, massively parallel computer system and software as well as advanced technologies for performances, as GPU's and fast SSD disks, shall be considered.

The Applicant(s) should give evidence of high level and acknowledged experience on the topics of the call. A detailed risk analysis of the proposed research project should be included.

1. Background

The regional aircraft market trends require more affordable products with reduced operational cost and higher level of eco-compliance increasing the competition among the aeronautical companies in the next years.

The development of new products that exploit the use of advanced composites, innovative structural architectures as well as recent findings in the fields of early damage detection and structural health management (JTI - GRA ITD , FP7 MAAXIMUS, FP7 SARISTU) could comply with the emerging market needs and create further opportunities to engage new customers.

Advanced composites offer promising benefits in terms of weight reduction, no corrosion, no fatigue, possible integration of additional functionalities in the same material otherwise addressed through the integration of dedicate add-on, increasing costs and weight.

For regional aircraft, the challenge is to meet the performance requirements as well as damage resistance, damage tolerance and vibration damping, addressed to minimum gage for pressurized fuselage with smaller radius, lower loads, nearer ground and operating in worse environmental conditions compared to wide body aircrafts.

Regarding structural health management recent efforts have been focused on the numerical modeling of methodologies for damage detection as well as on the technologies to implement them on structural components. Furthermore, new concepts of multifunctional materials (self-monitoring and self-healing composites) and smart repairing have been recently proposed in JTI - GRA ITD. The main limitation of the above findings is the unproved ability to operate properly in real complex structures (JTI – GRA ITD, SARISTU) and so to meet certification requirements.

2. Scope of work

Starting from the technology level matured in the framework of Clean Sky – GRA ITD, the scope of the work described in the present topic is to drive the integrated technologies and methodologies suitable for a composite regional aircraft fuselage towards their industrialization feasibility. To achieve this goal, the Core-Partner(s) shall address the development of technologies and methodologies to innovative solutions with increased structural integration, reduced total costs and structural weight, reduced environmental impact and extended duration of A/C life.

The activities will be performed in the following sub-topics:

- Sub Topic 1. Advanced methodologies and technologies for maintenance/repair and Non Destructive Inspection/Structural Health Monitoring (NDI/SHM);
- Sub Topic 2. Manufacturing & testing for Verification and Validation.

Sub Topic 1: Advanced methodologies and technologies for maintenance/repair and NDI/SHM

- **Objective: In the present Sub Topic advanced methodologies and technologies for maintenance/repair and NDI/SHM of composites shall be proposed by the Core-Partner(s) with the final aim of reducing the maintenance and repair times and costs in the service life, including solutions to facilitate the certification and overall component cost.**

To achieve the objective, the Core-Partner(s) shall develop methodologies and technologies for:

- self-monitoring and self-repairing of composite structures;
- health monitoring and inspection interval determination;
- residual strength assessment;
- structural degradation assessment;
- advanced repair technologies aimed at improving safety and reducing service costs.

Indeed, current limitations in the use of composite for manufacturing smaller size fuselages could be attributed to the lack of available methodology/technology to perform residual strength assessment for BVID defects (Figure 1).

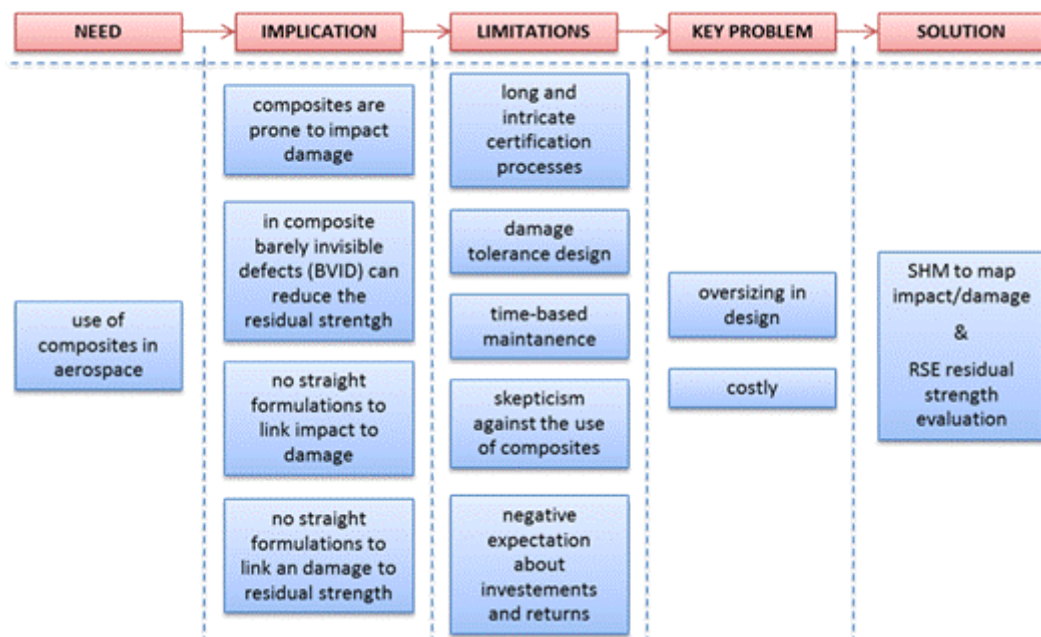


Figure 1

While in large aircrafts (A350, B787) the panel thickness, designed for the pressurization load, can easily withstand reduction of the residual strength after impact due to BVID (tool drop and hail in service), in smaller aircraft (A320, B737), where the panel thickness is smaller, BVID can drastically affect their residual strength and therefore reducing the aircraft safety.

To mitigate such limitations in the use of composites:

- BVIDs must be detected at an early stage without recurring to frequent visual inspections;
- The effect of such BVIDs on the residual strength of the damaged composite structure must be known.

An automated assessment procedure of the residual strength after impact for composite fuselage, applicable for different fuselage sizes and different level of defects (VID/BVID), could extend the use of composites in small aircraft.

In this context, the aim is to design and manufacture components with self-sensing properties in which manufacturing process control and damage assessment are made from production up to service through the assembly.

A unified NDI/SHM technique shall be proposed and the initial damage distribution recorded for the identified structural component health. Using appropriate NDI/SHM technologies, the sensing system should be able to detect with a very high probability of detection damages as VIDs as well as BVIDs.

The detection of all damages would lead the reduction of undetected/detected factor and consequently lighter structures could be addressed. The change in the response of the NDI/SHM system (sensors) as well as their optimal configuration should consider partially damage, environmental effects, operative conditions and structural repair.

In this approach these cornerstones shall be considered:

- Computational models for design analysis and optimization;
- Quality assurance during manufacture and assembly;

- In-service and during maintenance NDI/SHM evaluation.

New SHM technology validation shall be performed by the Core-Partner(s) using physical experimental tests performed in the Sub Topic 2 based on the building block approach. The SHM technology verification has to be done using an appropriate Virtual Test approaching 90/95% probability/reliability at each level of the building block. It requires millions of large scale computations, massively parallel computer system and relevant software: the Core-Partner(s) shall give evidence of appropriate and acknowledged experience in management of such type of activities. The Core-Partner(s) shall integrate SHM system developed in Sub Topic 1 on coupons, elements, fuselage sub-components designed with different architecture within Sub Topic 2: the weight has to be evaluated and demonstrated using building block approach.

An appropriate methodology has to be developed and applied for the operative cost estimation; the methodology has to consider SHM Probability of Detection (PoD); Probability of False Alarm (PoFA), Probability of Failure (PoF) operative cost model and, as constraint, safety aspects has to be considered.

The expected outcomes of this Sub Topic should significantly contribute to more effective use of composites with the aim to reduce weight and save operative cost. At the same time, the approach should offer the potential for a dramatic reduction in unscheduled maintenance by improving the reliability of structural prognosis.

The Sub Topic 1 is composed by:

- Sub Topic 1.1. Maintenance and Repair;
- Sub Topic 1.2. SHM: methodology;
- Sub Topic 1.3. SHM: technology.

Sub Topic 1.1 Maintenance and Repair

- **Objective:** The main objective of this Sub Topic 1.1 is to build, on the results of previous Clean-Sky, SARISTU and MAAXIMUS projects, an advanced repairing technology using smart repair concepts and an integrated methodology for the design and evaluation of a maintenance strategy.

To achieve the objective, the activities should include the latest technological enhancements together with upscale strategies from TRL 3 up to TRL 6. The Core-Partner(s) has to develop appropriate algorithms and software and test procedures, enabling validation and subsequent flight testing of the smart maintenance concepts.

The Core-Partner(s) has to consider all the possible damages on the composite fuselage; appropriate NDI technique and methodologies have to be proposed for the smart repair concept validation. Since the smart repair technology has to be finally applied to the regional aircraft composite fuselage, technology validation needs to be done following building block approach from material definition up to flight test through component and full scale curved panel representative of the full fuselage included in the Sub Topic 2.

The Core-Partner(s) has to include latest technological enhancements in magnetostrictive sensing, mainly in terms of materials used as sensors.

Due to the high complexity of these problems that include structural simulation of damage evolution and failure for damaged/repared composite components, High Performance Computing (HPC) with dedicated software/hardware resources shall be used. It is expected that these activities will exceed state of the art when applied to methodology verification and structural validation of complex structural system such a full scale fuselage demonstrator

The Core-Partner(s) shall to consider the following fields:

- 1) Definition of basic parameters and constraints, typical geometrical and material cases to be covered by the methodology and sensing requirements (strain sensitivity, spatial resolution etc.). CAMM in a wire form has to be examined, in order to select the most appropriate configuration for the extensive strain sensing of composite components, in terms of performance, cost, ability to be “knitted” in order to form a mesh etc. Additional properties of the metallic “mesh” should be examined, namely the lightning protection features, and specific materials will be selected in order to form the metallic mesh that will be able to simultaneous cover both the sensing and the LSP requirements.
- 2) Development and optimization of the sensor positioning i.e. arrays of magnetic flux sensing elements.
- 3) Numerical simulation of characteristic damage cases, in order to identify the surface strain profile that they produce. Based on the FEA database produced, surface strain measurements have to be correlated to internal damage, thus enabling structural health monitoring of components, especially in the case of structural repairs.
- 4) Development of appropriate sensing software and algorithms, in order to support the sensor data for the magnetic flux scanning, the magnetic flux of strain measurements, have to compare

the new to previous strain readings and correlate surface strain readings to internal damage, such as debondings, delaminations etc.

- 5) Manufacturing of repair of a component scale demonstrator, for the evaluation of the developed smart maintenance methodology. A three-dimensional artificial damage, (e.g. typical 2bay-crack damage - one stringer broken and the skin cracked on both sides of stringer - half-bay of skin on each side and the central stringer damaged), will be studied.
- 6) Flight-testing of the developed smart maintenance concepts for the magnetostrictive strain sensing methodology, reviewing of results and evaluation of the overall developed smart maintenance methodology using magnetostrictive sensors against set criteria has to be done.
- 7) Development of an integrated methodology for the evaluation and design of a maintenance strategy. The Core-Partner(s) should perform diagnostics and prognostics and inspection interval definition. Reverse engineering methodology has to be developed to build a diagnostic model that will be able to provide information on damages, Probability of Detection (PoD) and Probability of False Alarm (PoFA) and Probability of Failure (PoF). Damage information will be used to evaluate the future behavior of the structure and advise maintenance strategies.
- 8) Multilevel methodology for residual strength assessment and methodology/technology for the control of structural degradation and for composite structures with the aim to improve structure safety and service cost.

Sub Topic 1.2 SHM: methodology

- **Objective:** The Core-Partner(s) shall propose methodologies designed to optimize the maintenance stage as well as reduce maintenance costs. The Core-Partner(s) shall pave the work to demonstrate how methodologies can reach to TRL 6 within the project and can be scalable to aircraft level.

Thanks to their superior strength-to-weight properties, composite materials are vastly adopted in aerostructures. Unfortunately, composite aerostructures are prone to different types of damages such skin-to-stringer debonding and skin delamination/indentation, that even if they may appear invisible or scarcely visible at the structure surface (BVID), may have an extremely negative effect on the residual strength of the aerostructure. Thus, to keep the proper level of safety without recurring to unnecessary maintenance actions, industrial efforts have to focus on the development of integrated Structural Health Monitoring (SHM) technologies meant at detecting/characterizing in real-time damages at an early stage, in a totally non-invasive manner.

On this regard recent cutting-edge researches focus on SHM system based on modal strains measured via fiber optics to control class I defects, i.e. mainly skin-to-stringer debonding, and a stress guided waves driven by a network of piezoelectric (PZT) sensors to map defects, i.e. skin delamination and indentation. However, such techniques have been validated only on small components (composite stiffened flat panels) and require still major developments and testing for composites curved panels as well as for a full scale aircraft fuselage section. In particular the following topics have been addressed:

- (i) the optimum number of sensors;
- (ii) their best positions;
- (iii) their reliability/probability for damage detection;
- (iv) minimization of the operative costs toward structural safety
- (v) damage simulation, residual strength for components and whole fuselage.

To such aim, this Sub Topic has to develop advanced methodologies for defect detection, characterization, residual strength, damage simulation and operative costs estimation, non-linear finite element codes for large scale parallel computing should be exploit, the most advanced hardware resources in Europe should be proposed to support the design and validation and verification of a SHM system for a real scale composite fuselage section. This methodology has to take into account different types of damages, such as matrix cracking, fiber to matrix debonding, delamination, indenting and fiber rupture that can happen during maintenance and in service. The methodology has to demonstrate to work well in real environmental condition. The methodology has to be verified / validated on the base of building block approach and applied for the whole aircraft fuselage. The sensors installation has to be compliant with design and maintenance actions minimizing the operative costs. The sensor replacement actions has to be feasible and easy to be made (bonding of the sensors on the surface are suggested).

For this purpose, the following six main points should be addressed:

1. The Core-Partner(s) should provide a design platform for SHM for which a system tailoring is defined at the design stage to minimize operative costs; proper and multiphysics modelling of the components of the SHM systems should be foreseen;
2. development of methodologies for damage detection, localization and characterization in composite aircraft fuselage;
3. the proposed methodologies should be designed to operate on various damages (matrix cracking, fiber to matrix debonding, delamination, indenting and fiber rupture, multi damage) that may occur during manufacturing, in service or at the same maintenance stage;
4. the effect of real environmental effects (noise, temperature, humidity, operative loads, etc.) versus the high level of reliability and robustness needed by acceptable methodologies, have to be properly considered;
5. within the framework of the Building block approach paradigm, the Core-Partner(s) has to identify proper numerical and experimental based Verification and Validation procedures. To this purpose proper metrics capable to assess the methodological performance versus aeronautical requirements shall be defined;
6. to integrate methodologies for diagnosis into a life cycle approach for a composite fuselage final experimental tests for performance evaluation and methodology certification shall be identified. A mean to assess the final results shall be proposed.

Sub Topic 1.3 SHM: technology

- **Objective:** The Core-Partner(s) shall develop technologies for Structural Health Monitoring (SHM) scalable to the A/C level. Within the present Topic, technologies shall be verified and validate with the aim to reach TRL 6 at sub-component level (full scale curved stiffened fuselage panel)

The proposer has to identify a proper technology and/or system integration for the evaluation of the composite performances in terms of damage detection; three levels of interrogations have to be addressed:

- 1) Damage exist;
- 2) Damage position;
- 3) Damage dimension.

The technology has to be verified and validated to detect single and multiple damage at level of coupon, element, sub-component through tests performed in Sub Topic 2 and has to be scalable on a full scale regional fuselage.

Following the certification criteria for the structural probability of failure the following events have to be considered:

- Probable events which are likely to occur at least one time during the operational life of a number of airplanes of the same type. This corresponds to a probability of occurrence $P(E) > 10^{-5}$ / FH.
- Remote events which are unlikely to occur to each airplane during its total life but may occur when considering many aircrafts of the same type, with a probability of occurrence of $10^{-7} < P(E) < 10^{-5}$ / FH.
- Improbable events which are unlikely to occur when considering the total operational life of all airplanes, but need to be considered as possible, with a probability of occurrence of $10^{-9} < P(E) < 10^{-7}$ / FH.

The following technologies can be proposed by the Core-Partner(s):

- 1) piezoelectric based;
- 2) optical fiber based;
- 3) hybrid technology optical fiber plus piezoelectric;

To reach the above mentioned probable events an appropriate reliability approach have to be proposed to demonstrate the potentiality of the technology detecting different type of damage for different structural areas; 90/95% of probability/reliability have to be demonstrated. Technology

road map to achieve TRL 6 has to be shown mixing the methodology developed in Sub Topic 1.2 with the proposed technology developed in Sub Topic 1.3 and validated in Sub Topic 2.

In particular, the Applicant(s) in its proposal must successfully address the following points:

1. technology A/C compatibility issues including weight, electrical disturbance, cabling, power consumption, technology operational life as well as hardware over time reliability must be taken into account;
2. selection of proper hardware/software platforms, actuators and sensors, optimum number and position of sensors, sensors reliability as well as installation procedures, shall be identified by the Core-Partner(s)
3. technology functionality and performance verifications test shall be defined. Furthermore the C Core-Partner(s) has to identify the appropriate technology quality assessment from manufacturing to aircraft performance control through assembly and monitoring technology;
4. full scale test (functional test) have to be properly identified in order to verify the performances of the maintenance strategy. The validation performed by the Core-Partner(s), shall be verified at the full scale fuselage ground test.

Sub Topic 2: Manufacturing & testing for Verification and Validation

- **Objective:** The aim of the present Sub Topic is to drive the technologies (materials and processes) suitable for a fuselage regional aircraft developed in the framework of Clean Sky – GRA ITD to an industrialization phase. Furthermore, the verification of the numerical methods and technologies developed in the previous Sub Topic and the validation by numerical - experimental results correlation shall be carried out by the Core-Partner(s) up to sub-components level.

Starting from the main outcome of GRA ITD, the technologies readiness level of structural fuselage components such as skin/stringers, fittings, aft. pressure bulkhead, windows frames, floor structure shall be consolidated by the Core-Partner(s) in order to demonstrate their industrial feasibility.

Within LWC Domain of GRA ITD, technologies have been down selected starting from an initial TRL 3 up to the achievement of a TRL 6 for those technologies included and tested in full scale on-ground and in-flight demonstrations. The driver factors of GRA ITD technologies down selections have been focused on weight reduction, parts manufacturability in a planned timeframe and improvement of peculiar properties.

The above mentioned consolidation of TRL requested to the Core-Partner(s) within the present sub topic consists in the achievement of TRL 6 for all new technologies integrated in structural fuselage components taking into account also those driver factors indispensable for the industrialization: total costs reduction, production rate increase, automation increase in manufacturing and assembling.

- For fuselage skin/stringers, processes using automatic placement of pre-preg technique shall be used and the relevant technologies shall include the following functionalities:
 - Composite with a high impact resistance (tool drop, hail, debris, ...) by using tailored resin;
 - Embedded damping veil for acoustic improvements;
 - Embedded EME and Lightning features (as well as nano-materials or further suitable solutions);
 - Integrated thermal protection;
 - Passive damage warning (Coats/Paintings).
- For fittings, aft. pressure bulkhead, windows frames, floor structure, advanced processes typically used for high loaded parts and/or with complex shape such as RTM, thermoplastic forming shall be improved for industrialization.

As stated above, for all structural components, the advanced technologies development shall be driven by the following key factors: increase of integration, reduction of manufacturing costs, reduction of assembling costs, increase of robotization in manufacturing and assembling,

improvement of environmental aspects if compared to traditional processes.

The integrated processes and the relevant costs estimation for each component shall be assessed through the realization of dedicated manufacturing trials to be characterized in order to verify part quality repeatability.

The Sub Topic shall also include:

- improvement of repair solutions for material / technology selected, in particular:
 - 1) temporary and removable repair solutions,
 - 2) repair solutions suitable during production,
 - 3) repair solutions for maintenance.

- Integration of SHM/NDI systems for damages detection & monitoring evaluation.

The maturation of the above mentioned technologies up to the level suitable for components industrialization shall be demonstrated by means of an opportune test campaign based on an appropriate Test Plan. The Test Plan shall be defined following the building block approach and, aimed by virtual testing campaign, covering the following levels:

1. coupon level,
2. element level,
3. sub-component level.

The activities to be performed by the Core-Partner(s) for defining the Test Plan shall be addressed to the planning of tests to be performed for each item and for each level above identified. As reference, the expected items and tests are listed below.

Technologies, materials, processes for manufacturing of coupons, elements and sub-components shall be representative of the structural configuration to be adopted for different components of the new regional aircraft fuselage barrel: skin/stringers, fittings, aft. pressure bulkhead, windows frames, floor structure.

For example, skin/stringers shall include stringer run-outs and ply drop-offs and shall be representative for the window belt, bottom skin, crown skin, side skin and door surround skin.

Possible geometrical modifications of panels, relative to the fuselage design might be needed due to the load introduction during panel testing.

According to the Test Plan, material shall be characterized by means of standard tests performed on coupons for Level 1.

Structural details representative of skin/stringers, fittings, aft. pressure bulkhead, window frames, floor structure shall represent the items to be designed, manufactured and tested for Level 2.

Stiffened flat panels up to size 1,6 m x 1,0 m, and curved stiffened panels of dimension 5 m by 1.7 m

by 4.5 m radius shall be designed, manufactured and tested for Level 3 of the building block approach.

The design activities shall be performed according to the methodologies developed in Sub Topic 1. Furthermore the possible use of harvesting technology as well as wireless transducers should be considered. In addition, during testing the humidity and temperature effect must be taken into account.

Also tests to be performed on each item will be chosen according to sizing requirements.

Expected tests shall include, for reference:

- for Level 1, standard unidirectional tension, compression and shear, open hole compression, filled hole compression, open hole tension and filled hole, bearing, compression and tension after impact, interlaminar shear strength, interlaminar tensile strength, pull through.
- for Level 2, compression/tension on mono-stringer, T-pull on fitting, compression on aft. pressure bulkhead joint, tension on windows frame including in a panel bay, bending on floor beam (at least, 3 critical load conditions per each configuration of each item: mono-stringers, fittings, pressure bulkhead joint details, windows frames, floor beams).
- for Level 3, fatigue and static compression / buckling tests up to failure, fatigue and static tension tests up to failure, impact tests with different level of energy and different impact locations in severe environment (temperature, humidity).

For Level 3, with respect to technologies matured in GRA ITD LWC, as stated at the beginning of Sub-Topic 2, the design and manufacturing of stiffened flat and curved panels shall take into account solutions which facilitate the integration between fuselage structural items, allow the use of automatic fiber placement in manufacturing, allow the use of robots for assembling and, in general, allow a cost reduction to support the industrialization phase. As stated above, these drivers' factors shall be valid since Level 1.

All experimental results shall be included in respective Test Reports.

The proposed design approach shall be validated through comparison of the numerical activities with the experimental results of the sensorized damaged composite structure. It shall be demonstrated the ability of the installed SHM systems to predict location, type, extension of damage to an accuracy which allows reliable prediction of residual strength due to the impact load.

For particular aspects, the Core-Partner(s) will be allowed to propose Calls for Proposal and Calls for Tender to complete the above mentioned Sub Topics. Relevant sizing of activities budget shall take into account this opportunity.

Table 1 briefly summarizes the foreseen Technology Challenges:

COMPONENT	TECHNOLOGY CHALLENGES	TECHNOLOGY DEMONSTRATORS
Stiffened flat and curved panels (Level 3)	High Performance Computing (HPC) for hundreds runs in parallel	Regional Aircraft Fuselage
Stiffened flat and curved panels (Level 3)	Piezo electric sensors for damage detection	Regional Aircraft Fuselage
Stiffened flat and curved panels (Level 3)	Optical fiber for damage detection, innovative network/component architecture	Regional Aircraft Fuselage
Stiffened flat and curved panels (Level 3)	Suitable innovative hybrid technology for damage detection such as optical fiber as sensor of strain and lamb waves	Regional Aircraft Fuselage
Stiffened flat and curved panels (Level 3)	Innovative internal load monitoring using optical fiber	Regional Aircraft Fuselage
Stiffened flat and curved panels (Level 3)	Innovative external load monitoring network, using optical fiber	Regional Aircraft Fuselage
Stiffened flat and curved panels (Level 3)	Magnetic technique for strain monitoring addressing smart SHM / repair concepts	Regional Aircraft Fuselage
Stiffened flat and curved panels (Level 3: skin/stringers)	Composite incorporating functionalities as high impact resistance, acoustic improvements, EME and Lightning features, thermal protection	Regional Aircraft Fuselage
Stiffened flat and curved panels (Level 3: sub structures)	Suitable advanced Composite and Processes for high loaded parts and/or with complex shape	Regional Aircraft Fuselage
Stiffened flat and curved panels (Level 3: sub structures)	Suitable advanced technologies for homegeneous curing of large repair	Regional Aircraft Fuselage
Stiffened flat and curved panels (Level 3: sub structures)	Tecnology repair for thick structures surface preparationactivation	Regional Aircraft Fuselage
Stiffened flat and curved panels (Level 3: sub structures)	Health monitoring of repairs using sensors such us optical fibres, piezo, wirless sensors.	Regional Aircraft Fuselage
Stiffened flat and curved panels (Level 3: sub structures)	Magnetostrictives technology, surface preparation/activation	Regional Aircraft Fuselage

Table 1 – Technology Challenges

3. Intellectual Property

SECTION 3 of Clean Sky 2 JU "Multi-Beneficiary Model Grant Agreement for Members" shall be applied.

Any activity/deliverable that will be produced by the Core-Partner(s), that will be developed starting from requirements, analysis, or inputs from Alenia Aermacchi shall be considered as jointly generated as per para. 26.2 of said Multi-Beneficiary Model Grant Agreement for Members. Joint ownership of results shall be applied to the above described results.

4. Special skills, capabilities

- Acknowledge competence in the management of very articulated programme and capability of technical conduction of complex project.
- Proven experience in international R&T projects cooperating with industrial partners, institutions, technology centres, universities.
- Quality and risk management capabilities demonstrated through applications on international R&T projects and/or industrial environment
- Proven experience in the use of design, analysis and configuration management tools of the aeronautical industry (i.e. CATIA v5 release 21, NASTRAN, VPM)
- Experience with TRL Reviews or equivalent technology readiness assessment techniques in research and manufacturing projects for aeronautical industry

Moreover, the Core-Partner(s) shall have fields of expertise briefly summarized in the Table 2 the foreseen

	Field of expertise
Leadership	International proven experience leading in European project with wide expertise in management of research first level work package.
Designer and Stress Analyst	Proven competence in leading large-scale structural analysis, with emphasis on damage, impact, wave propagation.
Optimizer	Internationally leading specialists in numerical optimization.
Massive computation	Internationally leading HPC-specialists in HPC, large-scale dynamic non-linear structural analysis and advanced damage modelling
Manufacturer	Proven experience from manufacturing of substructures in form of a real scale A/C panels and integration of SHM systems.
NDI specialist	Proven experience on non-destructive inspections.
Experimentalist	Appropriate experience in experimental testing and in particular in impact and residual strength testing of stiffened composite panels.
Repair specialist	Proven experience in composites A/C repair.
Certifier	Proven experience in A/C certification and setting up inspection schemes.

Table 2 - Field of expertise

5. Major deliverables and schedule (estimate)

The Core-Partner(s) is (are) requested to provide deliverables for the proposed activities in accordance with the relevant Preliminary Schedules contained in the JTP.

The Core-Partner(s) activity start time is corresponding to T0 on 1st of April 2015. Core-Partner(s) contributions are requested to start from T0.

Therefore relevant Core-Partner(s) involvement is requested from T0 up to December 2021 (T0+81).

Deliverables			
Ref. No.	Title - Description	Type	Due Date
Sub Topic 1: Advanced methodologies and technologies for maintenance/repair and NDI/SHM			
D1	Structural requirements for fuselage design	Report	T0 + 6
D2	Operational requirements for SHM-instrumented fuselage	Report	T0 + 6
D3	HPC based platform architecture definition	Report	T0 + 12
D4	Test Plan provided according to the building block approach	Report	T0 + 12
D5	Selection of methodologies and technologies suitable for NDI/SHM	Report	T0 + 14
D6	Development of the HPC NDI/SHM platform for fuselage design	Report / SW / HW	T0 + 31
D7	Verification of the NDI/SHM systems functionality	Report	T0 + 37
D8	Verification of the NDI/SHM platform functionality	Report / SW / HW	T0 + 43
D9	Application of NDI/SHM to the regional fuselage test case	Report	T0 + 50
D10	Development of a virtual test module	Report / SW	T0 + 61
D11	Development of a module for the ultimate strength evaluation	Report/Software	T0 + 61
D12	SHM/NDI platform integration	Report / SW / HW	T0 + 63
Sub Topic 2: Manufacturing & testing for Verification and Validation			
D13	Realization of manufacturing trials to be characterized to verify part quality repeatability and assess the processes costs	Report	T0 + 09
D14	Design of coupons including sensor locations to be tested finalized	Report / CAD CAE Models	T0 + 14

Deliverables			
Ref. No.	Title - Description	Type	Due Date
D15	Coupons manufactured including NDI, SHM systems installed and ready for test	HW	T0 + 18
D16	Experimental tests performed on coupons and test report	HW / Test Report	T0 + 21
D17	Design of elements including sensor locations to be tested finalized	Report / CAD CAE Models	T0 + 21
D18	Elements manufactured including NDI, SHM systems installed and ready for test	HW	T0 + 28
D19	Experimental tests performed on elements and test report	HW / Test Report	T0 + 33
D20	Design of sub-components (flat and curved stiffened panels) including sensor locations to be tested finalized	Report / CAD CAE Models	T0 + 33
D21	Sub-components (flat and curved stiffened panels) manufactured including NDI, SHM systems installed and ready for test	HW	T0 + 39
D22	Experimental tests on sub-components completed and test report	HW / Test Report	T0 + 45
D23	Validation of design and structural analysis models and methods up to panel scale	Report	T0 + 49
D24	Application to a full scale regional aircraft fuselage	Report	T0 + 57
D25	Verification of the developed integrated platform that include: material process, Virtual test, ultimate strength and operative cost estimation	Report / SW	T0 + 79
D26	Final Report - Validation of the developed design platform with real scale full scale test at TRL 6	Report / SW	T0 + 81

Table 3 – Main Deliverables List

The following Table includes the major milestones to be achieved by the Core-Partner(s).

Milestones		
Ref. No.	Description	Due Date
Sub Topic 1: Advanced methodologies and technologies for maintenance/repair and NDI/SHM		
M1	Structural requirements for fuselage design	T0 + 6
M2	HPC based platform architecture definition	T0 + 12
M3	Development of the HPC NDI/SHM platform for fuselage design	T0 + 31
M4	Verification of the NDI/SHM platform functionality	T0 + 43
M5	SHM/NDI platform integration	T0 + 63
Sub Topic 2: Manufacturing & testing for Verification and Validation		
M6	Experimental tests performed on coupons and test report	T0 + 21
M7	Experimental tests performed on elements and test report	T0 + 33
M8	Experimental tests on sub-components completed and test report	T0 + 45
M9	Application to a full scale regional aircraft fuselage	T0 + 57
M10	Validation of the developed design platform with real scale full scale test at TRL 6	T0 + 81

Table 4 – Main Milestones List

As reference, Figure 2 shows the preliminary schedule of Airframe ITD WP B-4.3.

Figure 3 shows the preliminary schedule of Regional Aircraft ITD WP 3.2.

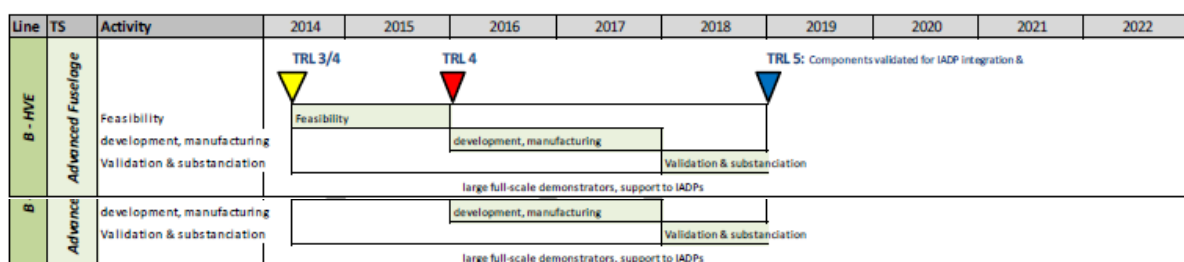


Figure 2 – Airframe ITD WP B-4.3 Preliminary Schedule

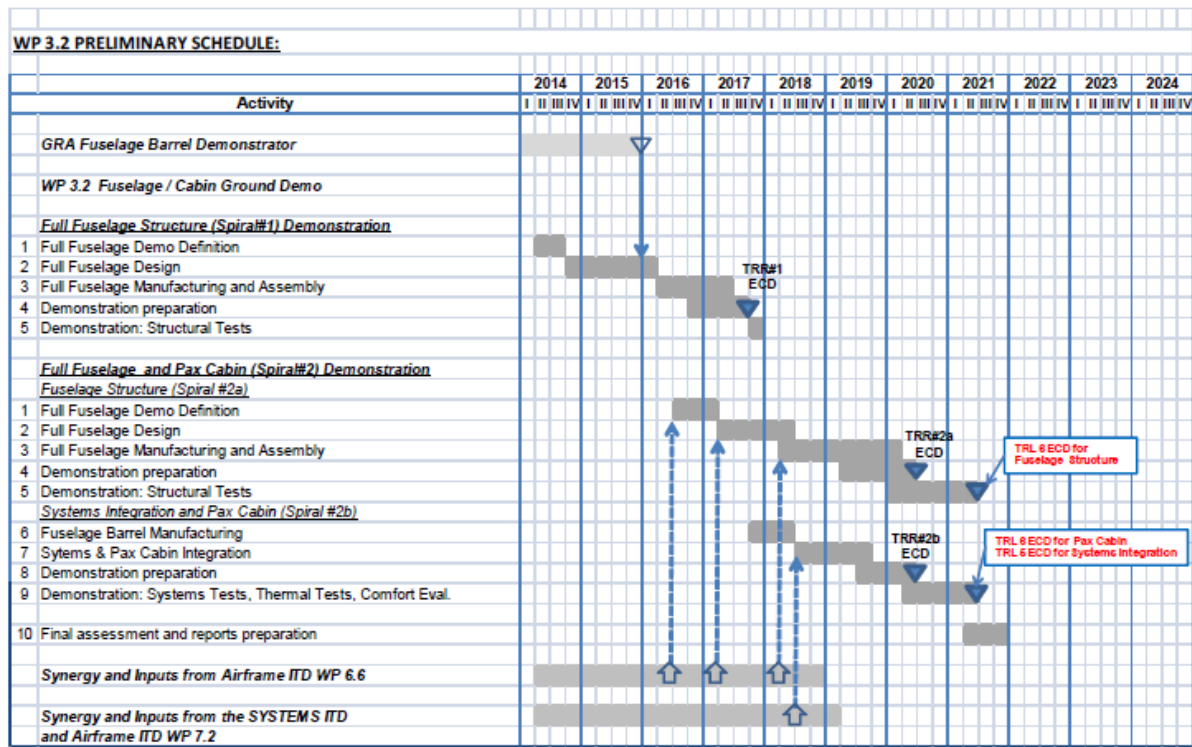


Figure 3 – Regional Aircraft WP 3.2 Preliminary Schedule

6. Acronyms

- BVID: Barely Visible Impact Damage
- CAD: Computer-Aided Design
- CAE: Computer-Aided Engineering
- CAMM: Curved anatomical M-mode of strain rate
- EME: Electromagnetic Emission
- FEA: Finite Element Analysis
- FP7: Framework Programme 7
- GPU: Graphics Processing Unit
- GRA: Green Regional Aircraft
- HW: Hardware
- ITD: Integrated Technology Demonstrators
- LSP: Lightning Strike Protection
- NDI: Non-Destructive Inspection
- RTM: Resin Transfer Moulding
- SHM: Structural Health Monitoring
- SSD: solid-state drive (disk)
- SW: Software
- VID: Visible Impact Damage.

VI. Design and Manufacturing of an Advanced Wing Structure for Rotorcraft Additional Lift

Leader and Programme Area [SPD]	Airbus Helicopters - AIR -ITD		
Work Packages (to which it refers in the JTP)	WP B-1.1		
Indicative Topic Funding Value	5,5 M€		
Leading Company	Airbus Helicopters		
Duration of the action	5,5 years [until end of LifeRCraft demo flights]	Start Date	April 2015
Date of Issue	13/6/2014	Call Wave	1

Topic Number	Title		
JTI-CS2-2014-CPW01-AIR-02-04	Design and Manufacturing of an Advanced Wing Structure for Rotorcraft Additional Lift	Duration	5,5 years
		Start Date	April 2015

Short description and terms of reference

The aim of the present topic is to develop manufacture and test wings in the frame of the ITD Airframe (WP HVE B1.1). The wing is a key structural element for the Fast Rotorcraft (Compound) and it is an innovative component for a rotorcraft. The intent is to benefit from the synergy with the activities developed in the framework of Fixed Wing in the Airframe ITD and to apply it on Fast Rotorcraft.

These wings will be implemented for integration test on ground and test in flight on the Compound Rotorcraft Demonstrator IADP LifeRCraft.

These wings should include trend setting manufacturing processes, innovative materials as well as an optimized design to meet the ecological challenges and to be sustainable for the environment, customer and industry.

The wings consists of

- Main structure (Spars, skins, fuselage attachment)
- Flaps over full wing-span (20% to 30% of chord)
- Structural provisions for Landing Gears, Propeller Gear Boxes, Flaps actuation, Propeller Drive Shafts
- Maintenance openings/covers

- Fairings (interface fuselage/wing, Propeller Gear Box, landing gear doors)

The major lay-out principles are focusing on

- Light weight design
- Certifiable design (CS29 is the baseline, special conditions could be required – not defined today)
- Stiffness of the wing system
- Aerodynamic performance (low drag, high lift)
- Dynamic behaviour influenced by the speed envelope, propeller and rotor interactions
- Removability

1. Background

The **LifeRCraft (IADP)** project aims at demonstrating that the compound rotorcraft configuration implementing and combining cutting-edge technologies as from the current Clean Sky Programme opens up new mobility roles that neither conventional helicopters nor fixed wing aircraft can currently cover in a way sustainable for both the operators and the industry. The project will ultimately substantiate the possibility to combine in an advanced rotorcraft the following capabilities: payload capacity, agility in vertical flight including capability to land on unprepared surfaces nearby obstacles and to load/unload rescue personnel and victims while hovering, long range, high cruise speed, low fuel consumption and gas emission, low community noise impact, and productivity for operators. A large scale flightworthy demonstrator embodying the new European compound rotorcraft architecture will be designed, integrated and flight tested.

In addition to the complex vehicle configurations, Integrated Technology Demonstrators (**ITDs**) will accommodate the main relevant technology streams for all air vehicle applications. They allow the maturing of verified and validated technologies from their basic levels to the integration of entire functional systems. They have the ability to cover quite a wide range of technology readiness levels.

This CfCoP belongs to the **Airframe ITD**, and herein to the **Activity Line 2: Demonstration of airframe technologies focused toward *High Versatility and cost Efficiency* (HVE).**

Within this Activity Line this CfCP is managed in the Work package HVE B-1.1 “*Wing for incremental lift & transmission shaft integration*”

2. Scope of work

This topic encompasses all the activities needed for developing and manufacturing the Wings within the ITD Airframe to be implemented on Fast Rotorcraft IADP. Therefore, activities such as engineering, manufacturing and testing are forming the scope of this call along with the relevant management activities.

The overall Roles and Responsibilities of the Core-Partner are as follow:

- **Technical Activities:** He is the Design- and Structural Manufacturing Responsible, therefore the

tasks and the WPs in which, completely or partially, the Core-Partner(s) will work are (Built to Spec):

- Development of the wing-concept within the boundaries of the AH-overall specification of IADP WP 2 Rotorcraft LifeRCraft **[HVE B-1.1.1]**
 - Development of the structural concept
 - Selection of materials and manufacturing processes (harmonized with AH)
 - Detailed layout and design
 - Substantiation concept (incl. tests)
 - Contributing to permit to fly
 - Support to ground- and flight tests

Note: the external shape of the wing and the fairing will be an input given by AH specification
- Manufacturing of all the Single Parts of the Wing **[HVE B-1.1.2]**
- Assembly **[HVE B-1.1.3]**
- **Managing and Coordination Activities:**
 - The Core-Partner(s) is (are) responsible as a member of the consortium according to the JU-Partner agreement documentation Manage & Coordinate directly all the WPS
 - Launch, Manage and Coordinate all the CfP and CfT, into the framework of the HVE B-1.1 Wing for incremental lift
 - Follow a Configuration Management process over entire program duration (details to be fixed during GAM-Phase)

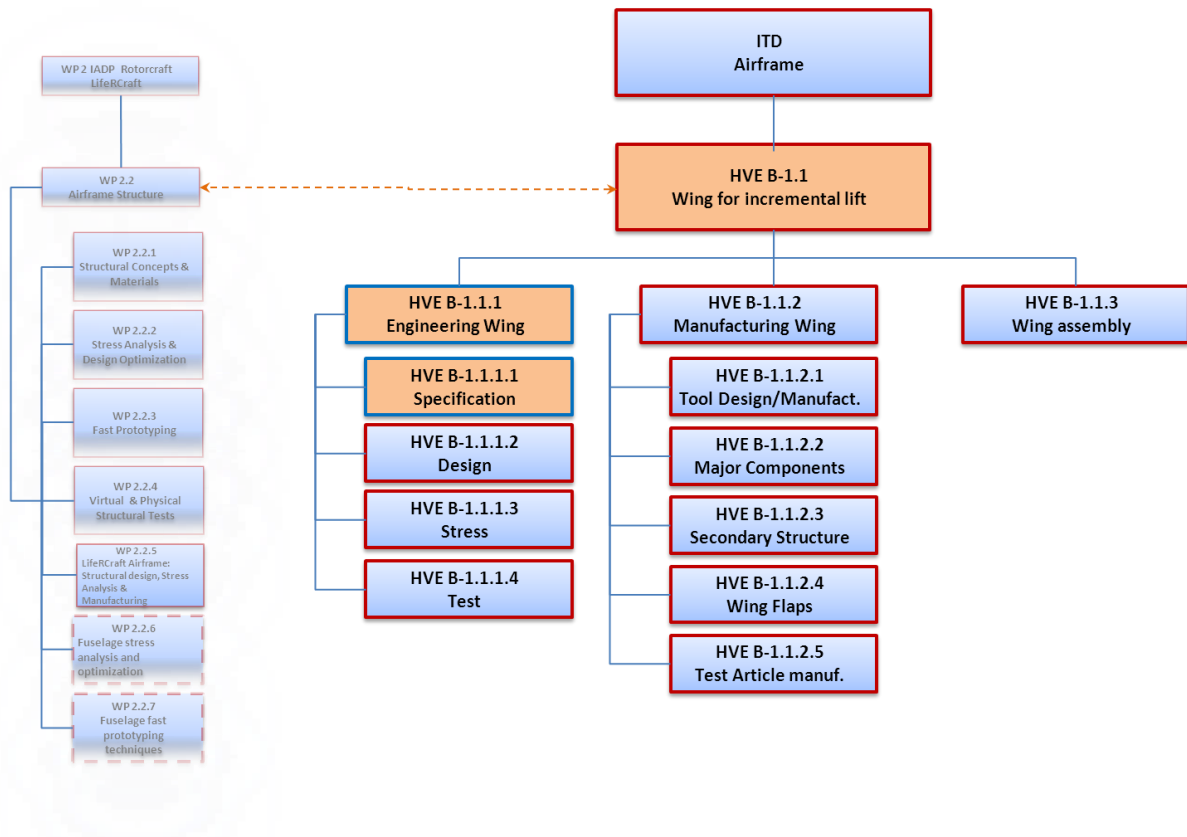


Diagram 1

Scope of the work is to develop and manufacture a light weight wing for a fast rotorcraft (compound helicopter), along eco-design principles.

The wing comprises the following main structural elements and all structural sub-elements belonging to it:

- Wing
 - Wing structure
 - Mechanical interfaces to Centre Fuselage
 - Mechanical interface to Propeller Gear Box
 - Mechanical interface to Wing Landing Gears
 - Provisions for sub-systems (eg. flaps and flap-actuation system, harnesses, hydraulic system, antennas, fairings, lightning protection, position light, transmission shaft , de-icing system, emergency floatation system, etc.)
- Flaps
 - Flap Structure
 - Mechanical interfaces to Wing and actuators

- Fairings
 - Propeller Gearbox Fairing
 - Maintenance Doors
 - Landing Gear Doors
 - Wing - Fuselage

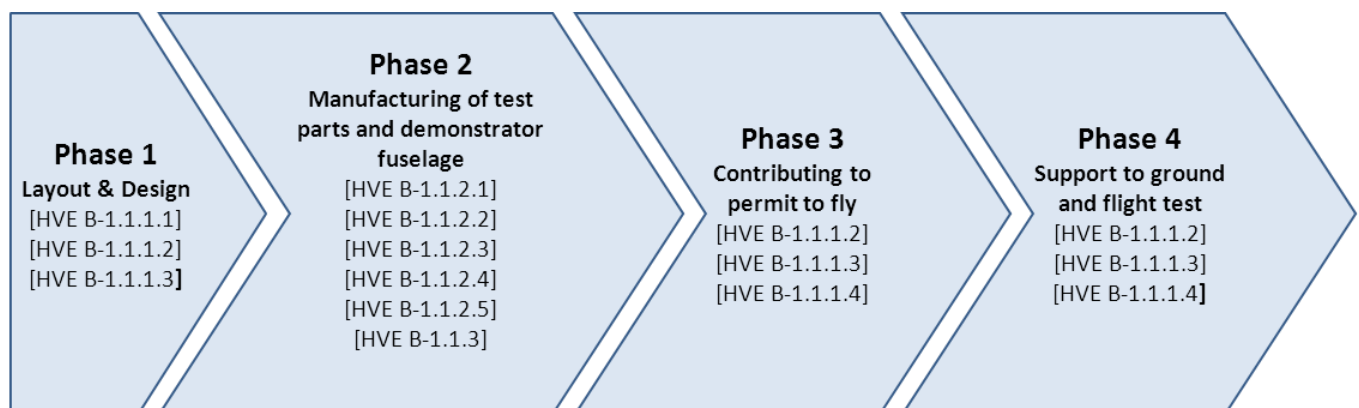
A dis-mounting and re-assembly of the wing has to be foreseen on shop level.

Note: The design of the wings has to cope with the specific physical requirements caused by the innovative anti-torque concept as well as the requirements typical of a conventional Helicopter e.g:

- High vibration level
- Un-steady aerodynamic flow
- Flight speed from 0 to 235 kts (max speed in dive tbd)
- High thermal loading due to exhaust gases
- Un-symmetric propeller thrust
- Un-symmetric lift at the wings possible
- Lateral landing velocity possible
- Rolling take-off and landing
- etc

Consequently the design of the wing could be non-symmetrical.

The work plan is structured into 4 project phases. Management will follow standard practices by applying reviews as PDR, CDR, TRR, QR etc.



Detailed description/content of the phases

The descriptions and details which will follow have been established under the assumptions that

- The selected Core-partner is certified CS21 (DOA and POA).

- The selected Core-partner is able to manufacture according the quality requirements which are standard in aeronautic industry (ref. Phase 3).
- If the above mentioned requirements are not satisfied, the certification of the partner according to CS21 has to be achieved 6 months prior to the delivery of the flyable parts at the latest. The acquisition of the certification has to be done under the partners own responsibility and at their own costs.

Phase 1

The main challenge during this phase is to satisfy all the requirements and boundary conditions for a high speed aircraft in ECO-design by designing a light weight and aerodynamically optimised structure. The recurring cost for a potential production also has to be addressed. The weight for the wing structure (both sides), including flap-structure and fairings should not exceed 300 kg (preliminary target for both wings).

The way how of achieving these targets is under the responsibility of the Core-Partner(s) and includes:

- Structural Architecture
 - Basic data regarding e.g. wing concept, wing surface, plan form, loft, type of aerodynamic profile, important interfaces, etc. are under the responsibility of AH.
- the selection of the used materials (Ref. to chapter 3)
- the selection of the manufacturing and assembly process (Ref to chapter 3)

Phase 1 comprises the **lay-out of the wing** and creating a set of **detailed drawings** and **substantiation documents** for the wing including all sub-elements (eg. LDG-doors, fairings, supports, provisions...). This includes, but is not limited to:

- performing architecture/structural layout (limited common design office at AH facility)
- performing detailed design
- responsibility of reaching the weight targets
- responsibility of achieving recurring cost estimations
- responsibility of structural layout and substantiation (static and dynamic)
- performing local loads distribution
- supporting aerodynamic design by ensuring the proper integration of single components (low drag)
- selection of material and process (harmonized with AH, see chapter 3)
- responsibility for manufacturing tools design
- definition of test components
- definition of the tests to be done before flyable wing delivery (harmonized with AH)

- perform life cycle assessment
- definition of inspection- and repair methods (to be approved by AH)

Several additional information sets (interface definition, external loads documentation, general requirement specification,...) prepared by AH will enable the partner to perform the task. A permanent support is envisaged.

In order to achieve a permit to fly, several harmonisation tasks and agreements have to be defined prior the start of phase 1. This comprises

- Engineering-Tool harmonisation (substantiation-tools defined by AH, IT, Program management, configuration management, . .)
- Quality assurance process harmonisation
- Communication management
- Dissemination of reports, technical documentation (e.g. substantiation documentation, test results, quality documentation, etc.)
- Modus vivendi of access rights for general documentation, information, quality reports, ...
- Co-development phase

Phase 2

Phase 2 will consist of the manufacturing of test parts, the demonstrator wings and if necessary an integration test wing.

Based upon the output of Phase 1 the hardware will be manufactured according to the agreed material- and tool selection.

Depending on the request of the IADP Airframe, sub-structural elements (e.g. Wing attachment elements) could have to be manufactured.

The Wing has to be assembled and fit checked as well as functionality test for, fairings, supports etc. have to be performed. The appropriate documentation and the approval of compliance have to be performed.

Phase 3

This phase is dedicated to meeting requirements for the LifeRCraft to obtain a “permit to fly”.

Since AH is the responsible party in front of the airworthiness agency, it is mandatory that AH will be supported in this role by the Core-Partner(s). Therefore, the main task of this phase is to contribute to the AH activities by supporting/delivering:

- Documentation to support AH in the process to obtain a permit to fly
 - Substantiation documentation for stress/fatigue/dynamic, vibration and bird strike

- Documentation for *flightworthiness* according to a *flight condition approval plan* (basis for flightworthiness are CS29 + special conditions (not yet defined))
- Tests reports tests (entire test-pyramid)
- Quality documentation for the delivered structural elements
- Quality substantiation documentation

Note: As the permit to fly documentation has to be endorsed by AH CVE's, a harmonization process with AH respective documentation has to be forecasted

- General Behavior of the wing (rigidity, deflection, etc....)
- Description of applied manufacturing processes

This phase includes the tests to be performed by the Core-partner at of the component's level (or sub-components) to contribute to the permit to fly.

Phase 4

This phase has two major tasks:

1. **Ground integration tests** performed to check the satisfactory behavior of the wings integrated with other aircraft components. The goals are to support the substantiation process, to demonstrate the achieved level of safety and to get the necessary data for analyzing the forecasted tests results. The delivered articles will incorporate the necessary test instrumentation;
2. **Flight tests** to demonstrate the successful achievement of the CS2-project objectives. The delivered articles will incorporate the necessary flight test instrumentation.

Both test-phases conducted by AH need the support of the Core-partner to ensure a direct link and reactivity in case of malfunctions, defects, improvements needed, etc.

Project synthesis

The Core-Partner has to participate and provide input to the project synthesis. It concerns particularly drawing the lessons learned from the demonstration evaluation, supporting the technical evaluation process (including Eco-design aspects) and participating in the evaluation of characteristics for a commercial product.

The above mentioned requirements and the IP process will be fixed in more details during the partner agreement phase.

3. Special skills, capabilities

- Requirements needed to achieve a permit to fly: capability to provide material data which are required to achieve a permit to fly

- Use of material, processes, tools, calculation tools etc. which are commonly accepted in the aeronautic industry and certification authorities (according the Test & Certification/Qualification Plan).
- Harmonization (AH- Core-Partner(s)) of calculation processes/tools
- Acting interactive with AH at any state of work
- Access to the production sites
- It is expected, that TRL level 4 is achieved for each system/technology proposed in 2015 at the latest. If this is not achieved on time, Core-Partner(s) has (have) to initiate a mitigation plan in order to reach the target of TRL 6 at the end of demonstration.
- The Core-Partner(s) has (have) to perform updates of documentation in case of in-sufficient content for authorities.

Special Skills

- Experience in design and manufacturing of structures in non-conventional and conventional composite materials (thermoset and thermoplastic plus high temperature systems) and innovative metallic components. (M)
- Capacity to assemble composite and metallic parts (aluminium, titanium ...); with hybrid joints.
- Design, analysis and configuration management tools of the aeronautical industry (i.e. CATIA v5 release 21, NASTRAN, VPM) (M)
- Competence in management of complex projects of research and manufacturing technologies. (M)
- Experience with TRL Reviews or equivalent technology readiness assessment techniques in research and manufacturing projects for aeronautical industry (M)
- Proven experience of collaboration with reference aeronautical companies with industrial air vehicle developments with “in – flight” components experience.(M)
- Experience of collaborating with industrial partners, institutions, technology centres, universities and OEMs (Original Equipment Manufacturer) within international R&T projects.(A)
- Capacity of providing large aeronautical components within industrial quality standards.(M)
- Capacity to support documentation and means of compliance to achieve experimental prototype “Permit to Fly” with Airworthiness Authorities (i.e. EASA, FAA and any others which may apply).(M)
- Experience in technological research and development in the following fields:
 - Innovative processes in composite materials (i.e. thermoset, ISC thermoplastic, thermo-forming, In-Situ Co-consolidation with no-welding, Out of Autoclave technologies).(M)
 - High Temperature Materials for Structural Applications, 135°C and more.(M)
 - Highly integrated structures (i.e. production rate, cost, and weight savings) (M).
 - Assembly (when applicable).
 - Process automation.(A)

- Capacity to specify material and structural tests along with the design and manufacturing phases such as material screening or panel type tests and instrumentation. (M)
- Capacity to perform structural and functional tests of large aeronautical components: test preparation and analysis of results (M)
- Capacity to repair components in shop to correct manufacturing deviations. (M)
- Capacity to support the global aircraft Configuration management. (A)
- Capacity of performing Life Cycle Analysis (LCA) and Life Cycle Cost Analysis (LCCA) of materials and structures. (A)
- Capacity of evaluating results in accordance with Horizon 2020 environmental and productivity goals following Clean Sky 2 Technology Evaluator rules and procedures. (A)
- Capacity of evaluating design solutions and results with respect to IAW Eco-design rules and requirements all along the project. (M)
- Design Organization Approval (DOA). (M)
- Product Organization Approvals (POA). (M)
- Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004) (M)
- Regulated facilities for the use of laser in manufacturing processes. (A)
- Qualification as Material and Ground Testing Laboratory of reference aeronautical companies (i.e. ISO 17025 and Nadcap). (M)
- Qualification as strategic supplier of structural test on aeronautical elements. (A)
- Technologies for composite manufacturing with OoA processes: e.g. RTM, Infusion, SQRTM Thermoforming, Roll-forming (M)
- Metallic manufacturing (A), including Additive Layer Manufacturing (A)
- Mechanical processes, in both composite material and metallic. Hybrid joints (CFRP + Metal) (M)
- Automatic Thermoplastic laying and In-situ Co-Consolidation equipment (A)
- Automated manufacturing process (i.e. Automated Fiber Placement, Automated Tape Lay-up, Dry Fibre pre-forming) (A)
- Manual composite manufacturing: hand lay-up (M)
- Assembly jigs and assembly process definition. (A)
- Tooling design and manufacturing for composite components. (M)
- Autoclaves and ovens (temperatures above 400 °C) as back-up solutions of composite components (parts of Ø2m and 6m) (A)
- Advanced Non Destructive Inspection (NDI) and large components inspection to support new processes in the frame of an experimental Permit to Fly objective: (M)
 - Dimensional and shaping inspections
 - Morphology studies of materials
 - Ultrasonic inspection capabilities
 - Additional NDI will be welcomed i.e.: Infrared (IR) Thermography, Laser Shearography, Laser ultrasonic inspection, X – ray Computed Tomography (XCT), ...
- Contactless dimensional inspection systems
- Simulation and Analysis of Tolerances and PKC/AKC/MKC (Product, Assembly and

Manufacturing Key Characteristics) (A)

M=Mandatory; A= Appreciate

Material and Processes:

In order to reach the main goals of the project, the two major aspects of maturity and safety have to be considered for materials and processes.

Because of the ambitious plan to develop a flying prototype in a short time frame, the manufacturing technology of the Core-Partner(s) must be at a high maturity level (TRL4) to safely reach the required technology readiness for the flying demonstrator.

To secure this condition, the Core-Partner(s) will have to demonstrate the technology readiness for his proposed materials and process and manufacturing technology with a TRL review, to be held together with AH.

The TRL review must be held within one year after the beginning of the project and must confirm a maturity of TRL5 (or at least TRL4 if a solid action plan to reach TRL5 within the scope of one further year is validated and accepted by AH).

Furthermore, the schedule of the project and the budget framework do not allow for larger unanticipated changes after the middle of the project. Therefore, it is required that, at the start of the activities, the Core-Partner(s) demonstrate(s) his capability to develop and manufacture the required items with a baseline technology (which can be e.g. Prepreg, RTM or lightweight Aluminium) as a back-up solution in case the new technology introduced proves to be too challenging.

This back-up plan, which is made to secure the accomplishment of the the project goals shall be agreed between AH and the Core-Partner(s) within half a year after the start of the activities.

Furthermore the M&P activities in the IADP and Airframe ITD shall support the safe inclusion of the Core-Partner(s) technology into the complete rotorcraft.

Certification:

- Design Organization Approval (DOA).
- Product Organization Approvals (POA).
- Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004)
- Qualification as Material and Ground Testing Laboratory of reference aeronautical companies (i.e. ISO 17025 and Nadcap).
- Qualification as strategic supplier of structural test on aeronautical elements.

General requirements on the wing

Main functions:

- Insure a significant part of the lift in cruise flight
- Support the PGB
- Include (part of WP)
- Flaps on each side with actuators (not coupled) for each side
- PGB fairings
- Landing gear doors
- Maintenance doors (shaft inspection, removal)
- Junction with main fuselage (Karman)
- Integration of (components not part of WP):
- Auxiliary LG
- Drive shaft with an intermediate bearing (minimum thickness, rigidity requirement, maintenance access)
- Harnesses
- Provisions for
 - Radio antennas (TBC)
 - Landing lights
 - Icing protection
 - Position lights/Radar/FLIR
 - Avionics equipment's
 - Emergency floatation
- Quality in accordance to a serial product

General requirements:

- High efficiency profile
- Removable for transport
- Bird strike resistance
- Lightning strike (direct & indirect)
- EMI protection
- Light weight
- CS29 + special conditions
- ECO Friendly materials & processes
- Quality in accordance to a serial product

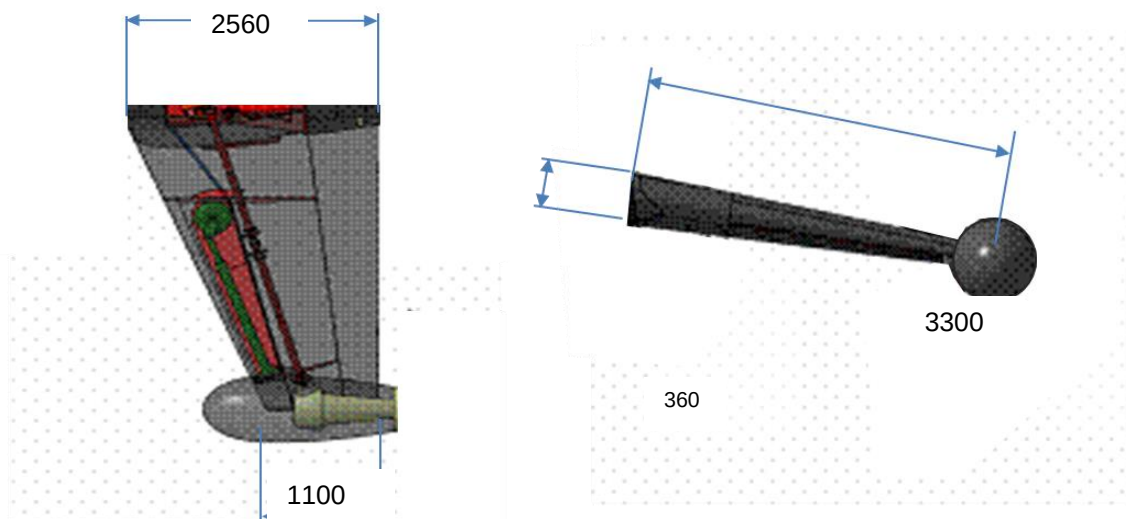


Figure 9 Dimensions (preliminary values)

Weight:

The target is to obtain the lowest weight possible for the proposed component compliant with the technical requirements and compatible with a serial aeronautical production.

In its offer, the applicant(s) shall provide an estimated maximum weight of its proposed component. This value will be updated for the signature of the consortium agreement regarding the design data available at this time. The difference with the weight provided with the offer will be substantiated and the new weight figure will have to be agreed with the leader

For the PDR, the core-partner will have to provide a detailed weight breakdown of the component in accordance with the technology, the technical requirement and the interfaces agreed with the leader. The difference with the weight agreed in the consortium agreement will be substantiated and submitted to the approval of the leader.

For the CDR, the Core-partner will provide an update of the weight breakdown with a substantiation of the difference with the PDR version. If an update of the overall weight is necessary, it will be submitted to the approval of the leader.

The components for the flying demo will be delivered with a weight record sheet and deviations from the target agreed during CDR will be substantiated.

At the end of the demonstration phase, the core-partner will provide a weight estimation of the component for serial production in accordance with the lessons learned during the demo phase. Differences from CDR weight have to be explained.

Recurring cost estimation:

The target is to obtain the optimum between the level of performances of the fast rotorcraft and the cost of the potential product.

For the PDR, the core-partner will provide an estimation of the recurring cost of the component on the basis of the assumptions given by the leader. An up-date will be provided for CDR and at the end of the demonstration phase.

External shape:

To maintain the overall drag of the fast rotorcraft at a low value is a strong challenge for the fast rotorcraft demonstrator. The external shape will be provided by the leader (3D CATIA model V5 R21). This shape is subject to change during the demonstration process after CFD analysis and/or wind tunnel tests. If changes are deemed necessary after the PDR, a retrofit solution of the demonstrator parts will be defined in accordance with the leader. Each change of the external shape requested by the core-partner has to be agreed by the leader.

Data management:

The leader will use the following tools for drawing and data management:

JET (ISAMI)

CATIA V5 R21

VPM compatible

SAP compatible



Topics for Core-Partners Call 1



The Core-Partner(s) will provide interface drawings and 3D model for digital mock-up in CATIA V5. The data necessary for configuration management have to be provided in a format compatible with VPM tool.

4. Major deliverables and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type	Due Date
ST5/D1	Structural trade-offs and Manufacturing Processes for LifeRCraft Wing - Analysis of architectural trade – off - Proposed materials and manufacturing processes	Report	T0 + 04&09
ST5/D2	Technical documentation supporting PDR of LifeRCraft Wing - Structural Analysis solutions - CATIA Models and drawings of solutions -Weight breakdown and associated substantiations - Recurring Cost estimation	Report Drawings	T0 + 09
ST5/D3	Technical documentation supporting CDR of LifeRCraft Wing - Structural Analysis solutions - CATIA Models and drawings of solutions - Weight breakdown and associated substantiations - Recurring Cost estimation	Report Drawings	T0 + 21
ST5/D4	Delivery of Parts and subassemblies(if apply) of LifeRCraft Wing for fuselage test purposes. - Quality inspection reports	Parts Reports Drawings	T0 + 30
ST5/D5	Delivery of Parts and subassemblies of LifeRCraft Wing - Parts ready for final assembly in “in-flight” Demonstrator - Weight assessment - Quality inspection reports	Parts Reports Drawings	T0 + 33
ST5/D6	Technical Documentation supporting Permit to Fly process with Airworthiness Authorities - Means of compliance	Reports Drawings	T0 + 39
ST5/D7	<i>Analysis of flight tests results and estimation of the characteristics of a serial product including the demo lessons learned</i>	<i>Reports Drawings</i>	<i>T0 + 63</i>

Core Partner Topic		2014	2015	2016	2017	2018	2019	2020
Core Partner Scope of Work	LifeRCraft IADP	Gen. Inputs	KoM		4			
	Phase 1 Layout & Design							
	Phase 2 Manufacturing of test parts & demonstrator fuselage							
	Phase 3 Contribution to Permit to Fly							
	Phase 4 Support to ground & flight tests							
Airframe ITD platform						5		

Timeline annotations: Gen. Inputs (2014), KoM (2015), PDR (2016), CDR (2017), Delivery to Assembly line (2017), TRIPHE (2018), Final Demo Review (2020).

5. Definition of terms

AH	Airbus Helicopters
CDR	Critical Design Review
CfCP	Call for Core-Partner(s)
CfP	Call for Partner
CfT	Call for Tender
CI	Configuration Items
CP	Core-Partner(s)
CSxy	Certification Specifications
DOA	Design Organization Approval
EMI	Electro Magnetic Interference
GAM	Grant Agreement for Members
HTP	Horizontal Tail Plane
HVE	High Versatility and Cost Efficiency
IAW	In Accordance With
JTP	Joint Technical Proposal
LCA	Life Cycle Analysis
LG	Landing Gear
LifeRCraft	Low Impact Fuel Efficiency Rotor Craft
PDR	Preliminary Design Review
PGB	Propeller Gear Box
POA	Product Organization Approval
QG	Quality Gate
RR	Roles and Responsibilities
WAL	Work Area Leader
TRL	Technology Readiness Level
TRR	Test Readiness Review
WBS	Work Breakdown Structure
WP	Work Package

Clean Sky 2 – Engines ITD

I. Low Pressure Turbine Rear Frame and Low Pressure Spool Shaft for Ultra High Propulsive Efficiency (UHPE) Demonstrator for Short / Medium Range aircraft

Leader and Programme Area [SPD]	ENG		
Work Packages (to which it refers in the JTP)	WP2 Ultra High Propulsive Efficiency (UHPE) Demonstrator for Short / Medium Range aircraft		
Indicative Topic Funding Value	5 M€		
Leading Company	SAFRAN/Snecma		
Duration of the action	9 years	Start Date	1 st April 2015
Date of Issue	July 9 th 2014	Call Wave	1

Topic Number	Title		
JTI-CS2-2014-CPW01-ENG-01-01	Low Pressure Turbine Rear Frame and Low Pressure Spool Shaft for Ultra High Propulsive Efficiency (UHPE) Demonstrator for Short / Medium Range aircraft	Duration	9 years
		Start Date	1 st April 2015

Short description and terms of reference

The present topic refers to the Joint Technical Proposal (JTP V4), addressing the System and Platform Demonstrators (SPD):

- **Integrated Technology Demonstrator (ITD) Engine - WP2.** Ultra High Propulsive Efficiency (UHPE) propulsion system technologies demonstrator for Short / Medium Range aircraft (SMR). In this Clean Sky 2 ITD, SAFRAN/Snecma is the leader of a Ground Test Demonstrator (GTD) of UHPE



An UHPE demonstrator candidate

WP2 aims at reaching TRL 5-6 maturation by mid-2021 for a set of specific technologies dedicated to UHPE concept. The chosen architecture is an Ultra High Bypass Ratio turbofan (ducted architecture) with a by-pass ratio preliminary anticipated within the range of 15-20. The purpose of this WP is to:

- Demonstrate and validate the overall performances (Specific Fuel Consumption, etc.) of the UHBR concept by assessing mainly the parts brought by the low pressure components measured in actual engine environment
- Obtain certain characteristics of the new modules as well as their mechanical and dynamic behaviour in the actual engine environment
- Obtain acoustic data from engine ground test to consolidate noise benefits at aircraft level

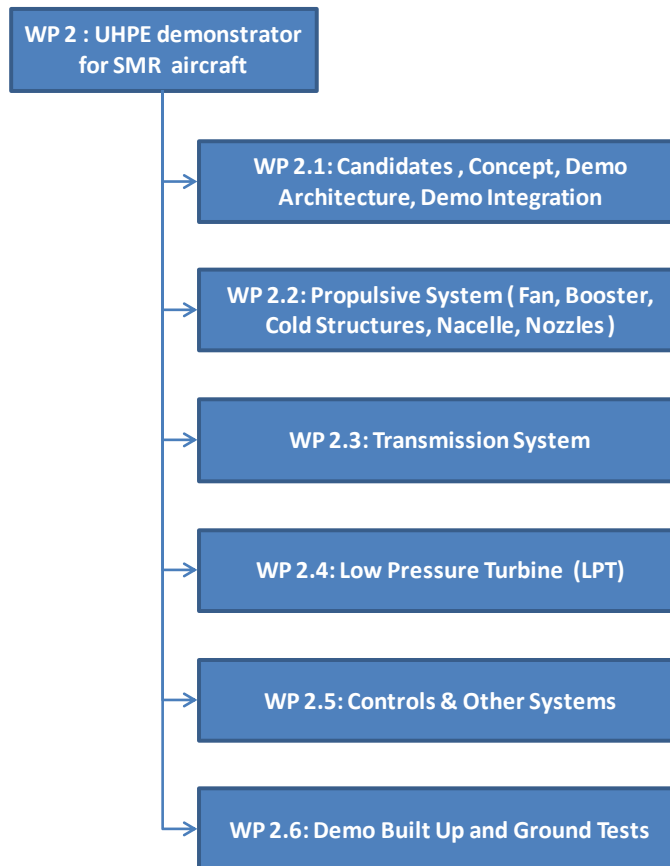
This topic includes design, manufacturing, instrumentation of the Low Pressure Turbine Rear Frame (TRF) and Low Pressure Spool (LPS) Shaft for UHPE GTD and test support for UHPE GTD. Innovation is required to develop a structural light weight Turbine Rear Frame (TRF) component.

In the frame of this Call for Core-Partner(s), the Applicant will be responsible for the tasks linked to the Low Pressure TRF and Low Pressure Spool (LPS) Shaft:

- **Low Pressure Turbine Rear Frame (TRF) and Low Pressure Spool (LPS) Shaft for Ground Test UHPE Demo Engine (GTD):**
 - Design the TRF and LPS modules/parts
 - Manufacture the TRF and LPS modules/parts
 - Assembly and Instrumentation of the TRF and LPS modules/parts
 - Support the Ground Test of the UHPE Demo Engine for the TRF and LPS modules/parts
- **Low Pressure Spool Shaft (LPS) for Scale 1 Component Tests:**
 - Manufacture the LPS module/parts and rig adaptations
 - Assembly and instrumentation of the LPS module/parts and rig adaptations
 - Scale 1 Component Tests: These tests are mechanical structural tests aiming at demonstrating the mechanical capacity of the shaft. They can be static tests or dynamic fatigue test (This is to be Defined)

The associated tasks are part of WP2.1, WP2.3, WP2.4 and WP2.6 as described in the Work Breakdown Structure (WBS) hereafter:

Topics for Core-Partners Call 1



1. Background

UHPE GTD includes a Low Pressure TRF and a LPS Shaft. Both are linking respectively:

- The Low Pressure Turbine (LPT) case with the primary engine nozzle supporting LPS aft bearing. TRF may transmit engine torques and forces to the engine mounting system, depending on the design of the whole Integrated Propulsion Powerplant System. This TRF, as a structural module, will support several functions; for instance the lubrication of the bearings, the air sump feeding/and or the exhaust, aft mounting system interface. These functions will require equipment such as the oil and tubes, bearing supports, oil injectors, equipment supports. The design of the TRF and its equipment shall integrate the flight test constraint, so that this design can be re-used after the Ground Test for a future potential Flight Test Demo (FTD) of UHPE.
- The rotor of the LPT with the Power GearBox (PGB) input shaft in order to transmit LPT torque to fan and Intermediate Pressure (IP) compressor modules via PGB.

2. Scope of work

The scope of work deals with the following strategic objectives:

- **On the Engine Side**, propose, select and test the TRF and LPS concepts which will be part of and fit with the optimized concept of UHPE
- **On the Module Side**, mature robust, efficient and lightweight TRF and LPS Shaft technologies, up to TRL6 through Ground Testing of TRF and LPS of the UHPE Demonstrator in order to demonstrate and validate the overall performances (specific fuel consumption, etc.) of the Ultra-High Bypass-Ratio (UHBR) concept by assessing mainly the parts brought by the LP components measured in actual engine environment
- *As part of WP2.1 of the ITD Engine (candidate, concept, demo architecture, demo integration), this will cover:*
 - Studies of best candidates for High Propulsive Efficiency Propulsion Powerplant System concepts, including nacelle aspects
 - Preliminary studies and choice of demo concept adequate to mature UHPE concept, taking into account the use of an existing High Propulsive core engine and nacelle aspects, leading to issuance of demo specifications
- *As part of WP2.3 of the ITD Engine (Transmission System) and in relationship with WP2.1, this will cover:*
 - Concept study of UHPE LPS Shaft
 - Preliminary Design of LPS Shaft
 - Design of LPS Shaft
 - Material and processes feasibility and characterization tests
 - Manufacturing of:
 - One LPS Shaft for UHPE GTD Engine
 - One LPS Shaft for scale 1 component test
 - Assembly and instrumentation of UHPE LPS for scale 1 component tests
 - Scale 1 component tests of UHPE LPS.
- *As part of WP 2.4 of the ITD Engine (Low Pressure Turbine) and in relationship with WP 2.1, this will cover:*
 - Concept study of UHPE Low Pressure TRF module
 - Preliminary Design of Low Pressure TRF module including its equipment
 - Design of Low Pressure TRF module including its equipment
 - Material and Processes feasibility and characterization tests
 - Manufacturing of one Low Pressure TRF module including its equipment for UHPE GTD Engine
- *As part of WP2.6 of the ITD Engine (Demo Built Up and Ground Tests), this will cover:*

Topics for Core-Partners Call 1



- Assembly and instrumentation of equipped TRF module for UHPE GTD Engine
- Support during UHPE GTD Engine, that includes:
 - o Participation in reviews before test (Test Readiness review) for TRF and LPS
 - o Monitoring of TRF and LPS parameters during the UHPE Ground Test
 - o Participation in the inspection of the TRF and LPS parts if needed
 - o Repair or replacement of TRF and LPS parts and measurements if needed
 - o Delivery of test report for TRF and LPS parts

3. Special skills, capabilities

- Expertise and skills
 - Design of aeronautic commercial engine structural parts or modules: aerodynamics, thermal mechanics, vibrations
 - 3D modelling and 3D CFD
 - Manufacture of aeronautic commercial engine structural parts or modules
 - Manufacture of aeronautic commercial engine rotating parts
 - Inspection means and expertise for quality assessment of produced part
 - Material characterization especially for fatigue characteristics (HCF, LCF)
 - Instrumentation and mechanical component test capability
 - Quality manual to ensure quality of design, materials, manufacturing, instrumentation, test, conditioning and shipping of hardware
 - Risk analysis, failure mode and effect analysis
 - Demonstrated capability to deliver structural frames and rotating parts able to be integrated on an actual scale 1 Flying Test Bed

- Capabilities and track records
 - Company qualified as an aeronautic supplier for product commercial engine parts
 - Company certified for Quality regulations (ISO 9001, ISO 14001) and for Design of engine subsystems or modules (CSE, Part 21, Part 145)

- Competences to deal with risks associated to the action

At SPD level:

 - Background in Research and Technology (R&T) for aeronautics especially on Turbofan Demonstrators and Structural and Rotating parts
 - Lessons learnt on achievements in the frame of former R&T European programmes (FP7 or Clean Sky): delivery of instrumented part(s) or module(s) for scale 1 engine demonstrator
 - Experience on design, manufacturing and testing of large structural engine parts (outer diameter 1m., weight 200kg)

- At applicant level:

 - Background in R&T for aeronautics
 - Lessons learnt on former R&T European program (FP7 or Clean Sky)
 - Project Management capability for 10M€ project
 - Quality Management capability for 10M€ project
 - Exchange of technical information through network: 3D models of parts, Interface Control Documents, Digital Mock-Up, 3D models available at CATIA format

- Expertise
 - Available in the internal audit team

- Resources in house for design, manufacturing, material, instrumentation, tests
- Intellectual property and confidentiality
 - Snecma will own the specification, while the Core-Partner(s) will own the technical solutions that he will implement into the corresponding subsystems.
 - Snecma information related to this programme must remain within the Core-Partner(s); in particular, no divulgation of this topic to Core-Partner affiliates will be granted.
- Ownership and use of the demonstrators
 - The Core-Partner(s) will deliver demonstrator parts to Snecma. Each part integrated or added in the demonstrator will remain the property of the party who has provided the part.
 - Notwithstanding any other provision, during the project and for five (5) years from the end of the project, each party agrees to grant to Snecma a free of charge right of use of the relevant demonstrator and its parts.
 - After the end of the period, each party may request the return of the parts of the demonstrator(s) that it provided. If the concerned parts are returned, no warranty shall be given or assumed (expressed or implied) of any kind in relation to such part whether in regard to the physical condition, serviceability, or otherwise.

4. Major deliverables and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type	Due Date
D1	Low Pressure TRF module and LPS Shaft for UHPE GTD: Concept study and feasibility report	R and RM	Q4 2015
D2	Low Pressure TRF module and LPS Shaft for UHPE GTD: Demo specifications	R and RM	Q3 2016
D3	Low Pressure TRF module and LPS Shaft for UHPE GTD: Preliminary Design Review and report	R and RM	Q4 2017
D4	Low Pressure TRF module and LPS Shaft for UHPE GTD: Critical Design Review and Detailed Design Report	R and RM	Q4 2018
D5	Results of partial tests, material tests for technology maturation and assessment: Tests Report	R and RM	Q2 2018
D6	LPS Shaft for UHPE GTD component tests plan and scale 1 component Tests Readiness Review	R and RM	Q2 2019
D7	LPS Shaft: hardware delivery to component test facility	D	Q3 2019
D8	LPS Shaft: component testing completed: - completed with hardware - inspection review and report	RM	Q2 2020
D9	LPS Shaft: component test reports	R	Q3 2020
D10	Equipped Low Pressure TRF module and LPS Shaft: hardware delivery to engine assembly stand	D	Q3 2019
D11	Engine readiness review Documentation for Low Pressure TRF module and LPS Shaft: - Delivered Hardware status - Instrumentation - Engine Test Plan requirements	R and RM	Q3 2020
D12	Engine Ground Test report for Low Pressure TRF module and LPS Shaft	R	Q3 2021
D13	Lessons learnt for Low Pressure TRF module and LPS Shaft	R	Q3 2021

*Type:

R: Report

RM: Review Meeting

D: Delivery of hardware/software

Topics for Core-Partners Call 1



5. Schedule

	2014		2015				2016				2017				2018				2019				2020				2021				2022			
Quartile	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Studies of best candidates for High Propulsive Efficiency PPS concepts, incl. nacelle aspects																																		
Preliminary studies and choice of demo concept adequate to mature UHPE concept (use of existing HP core & incl. nacelle aspects)																																		
Preliminary design																																		
Detailed design																																		
Demo instrumentation, assembly & bench update																																		
Manufacturing																																		
Ground test																																		
Result analysis																																		
TRL Progresses																																		

II. WP2 Ultra High Propulsive Efficiency (UHPE) Demonstrator for Short / Medium Range aircraft

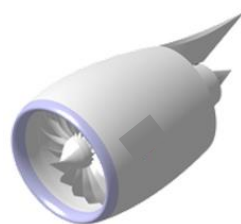
Leader and Programme Area [SPD]	ENG		
Work Packages (to which it refers in the JTP)	WP2 Ultra High Propulsive Efficiency (UHPE) Demonstrator for Short / Medium Range aircraft		
Indicative Topic Funding Value	5 M€		
Leading Company	SAFRAN/Snecma		
Duration of the action	9 years	Start Date	April 1 st 2015
Date of Issue	July 9 th 2014	Call Wave	1

Topic Number	Title		
JTI-CS2-2014-CPW01-ENG-01-02	Power GearBox (PGB) for Ultra High Propulsive Efficiency (UHPE) Demonstrator for Short / Medium Range aircraft	Duration	9 years
		Start Date	April 1 st 2015

Short description and terms of reference

The present topic refers to the Joint Technical Proposal (JTP V4), addressing one Systems and Platforms Demonstrator, the ITD Engine -WP2- Ultra High Propulsive Efficiency (UHPE) propulsion system technologies demonstrator for Short / Medium Range aircraft [SMR].

In this Clean Sky 2 ITD, SAFRAN/Snecma is the leader of a Ground Test Demonstrator (GTD) of UHPE.



An UHPE demonstrator candidate

WP2 aims at procuring TRL 5-6 maturation mid 2021 for a set of specific technologies dedicated to the UHPE concept. Chosen architecture is an Ultra High Bypass Ratio (UHBR) turbofan (ducted architecture) having a by-pass ratio preliminary anticipated within the range 15-20. The purpose of this WP is to:

- Demonstrate and validate the overall performances (Specific Fuel Consumption, etc.) of the UHBR concept by assessing mainly the parts brought by the low pressure components measured in actual engine environment
- Obtain some characteristics of the new modules as well as their mechanical and dynamic behavior in actual engine environment
- Obtain acoustic data from engine ground test to consolidate noise benefits at aircraft level.

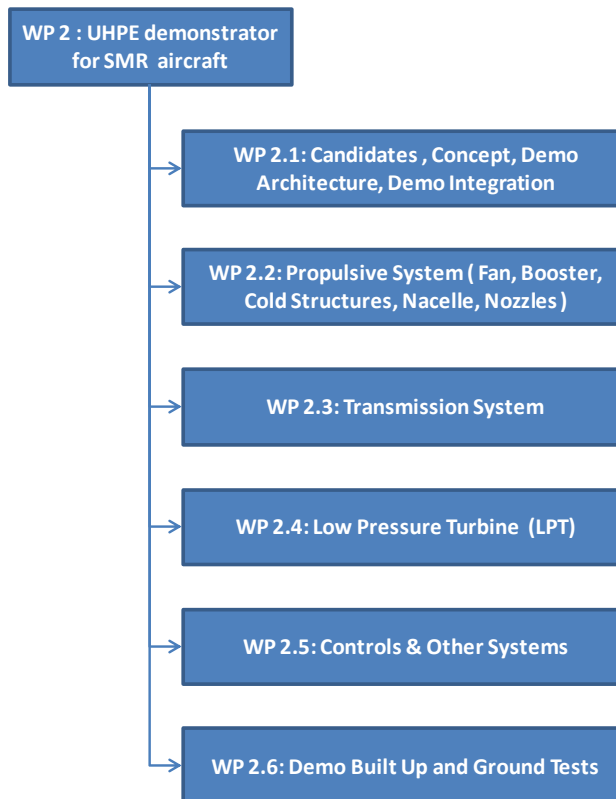
This topic includes design, manufacturing, instrumentation and rig test of the **alternative Power GearBox Module (PGB)** for UHPE Ground Test Demo (GTD). Innovation is required for this high power high density PGB in order to get a significant advantage versus competition in terms of weight of the whole PGB module including oil and oil equipment. For this reason, UHPE GTD Oil Sump and PGB potential equipment such as Oil Transfer Bearing (OTB) are part of this topic.

In the frame of this Call for Core-Partner(s), the Applicant(s) will be responsible for the tasks linked to the **PGB Module**:

- **PGB Module for Ground Test UHPE Demo Engine (GTD)**
 - Design of the PGB Module/parts and its equipment (Oil Sump, Oil Equipment, potential equipments such as Oil Transfer Bearing (OTB) for Ground Test UHPE Demo Engine (GTD)
 - Manufacturing of the PGB module/parts and equipment for Ground Test UHPE Demo Engine (GTD)
 - Assembly and Instrumentation of the PGB module for Ground Test UHPE Demo Engine (GTD)
 - Delivery of the equipped PGB module of the UHPE Demo Engine to SAFRAN/Snecma in a storage container.
- **PGB Module for Scale 1 Component Tests**
 - Design of rig adaptations for Scale 1 Component Tests
 - Manufacturing of two PGB Modules and of rig adaptations for Scale 1 Component Tests
 - Assembly and instrumentation of the PGB module/parts and rig adaptations for Scale 1 Component Tests
 - Scale 1 Component Tests: These tests are rotating, mechanically loaded, back-to-back tests aiming at demonstrating mechanical capacity of PGB parts and Module.

The associated tasks are part of WP2.1, WP2.2, WP2.3 and WP2.6 as described in the WBS hereafter:

Topics for Core-Partners Call 1



1. Background

UHPE GTD includes a PGB. This PGB is linking respectively the LP Turbine and the fan module and eventually the booster module depending on architecture of the whole Integrated Propulsion Powerplant System. This PGB, as a transmission geared system, will allow several functions as for instance lubrication of the gears and bearings, air sump feeding /and or exhaust. These functions will require equipment such as oil and tubes, bearing supports, oil injectors, oil transfer bearings, equipment supports. Design of PGB and its equipment shall integrate geometric and functional constraints in the UHPE GTD and also flight test constraints, so that this design can be re-used after Ground Test for a future potential Flight Test Demo of UHPE.

The **PGB Module** consists mainly in:

- A PGB with its input and out shafts
- Its Oil Sump
- Its equipment such as Oil Transfer Bearings if any, oil and tubes, bearing supports, oil injectors, equipment and instrumentation supports

The baseline PGB of the UHPE Ground Test Demo Engine is a SAFRAN product. Nevertheless, for assessment of alternative technology, this PGB -topic of this Call for Core-Partner(s)- will be rig tested at Scale 1 in the frame of this Call and will provide a spare PGB module for risk mitigation of UHPE Ground Tests.

2. Scope of work

The Scope of work deals with the following strategic objectives:

- **On Engine Side:**
 - to propose, select and manufacture and deliver the Alternative PGB Module concept that will be part of and fit with the optimized concept of UHPE.
 - to design, manufacture and deliver the Alternative PGB Module for the UHPE GTD that will allow a comparative assessment in terms of global performance versus the GTD PGB Baseline configuration and will be a risk mitigation for the GTD campaign.
- **On Module Side:** to mature robust, highly efficient and lightweight PGB Module Technologies, up to TRL5 through Rig Test of the alternative PGB of the UHPE GTD.

As part of WP 2.1 of ITD Engine (Candidate, Concept, Demo Architecture, Demo Integration), this will cover:

- Studies of best candidates for High Propulsive Efficiency PPS Concepts, including nacelle aspects
- Preliminary Studies and choice of demo concept adequate to mature UHPE concept taking into account the use of an existing HP core engine and nacelle aspects, leading to issuance of Demo Specifications.

As part of WP 2.3 of ITD Engine (Transmission System) and in relationship with WP 2.1, this will cover:

- Concept study of UHPE PGB Module including its equipment
- Preliminary Design of UHPE PGB Module including its equipment
- Design of UHPE PGB and its equipment
- Material and Processes feasibility and characterization tests
- Manufacturing of:
 - One PGB and its equipment as a spare Module for UHPE Ground Test Demo Engine(GTD)
 - Two PGBs and their equipment for Scale 1 rig test (rotating, mechanically loaded, back-to-back test).
- Design and Manufacturing of Scale 1 Rig Test Adaptations (forward and aft adaptation sleeves, driving shafts, bearings, bearing supports, oil and air sumps)
- Assembly and instrumentation of two UHPE PGB modules for Scale 1 Rig Tests
- Scale 1 Rig Tests of UHPE PGB Module.

As part of WP 2.6 of ITD Engine (Demo Built Up and Ground Tests), this will cover:

- Assembly and instrumentation of one UHPE PGB Module as a spare for UHPE GTD Engine
- Delivery of the equipped PGB module of the UHPE GTD Engine to SAFRAN/Snecma in a storage container
- Support during UHPE GTD Engine, that includes:
 - Participation in reviews before test (Test Readiness review) for Alternative PGB Module if needed
 - Participation in inspection of Alternative PGB Module if needed

3. Special skills, capabilities

▪ **Expertise and skills**

- Design of aeronautic commercial engine high Power high density geared systems: lubrication, thermal mechanics, vibrations
- 3D modeling and 3D CFD
- Manufacturing of aeronautic commercial engine structural and rotating parts or modules including gears
- Inspection means and expertise for quality assessment of produced part
- Material characterization especially for fatigue characteristics (HCF, LCF)
- Instrumentation and mechanical component test capability
- Quality manual to ensure quality of design, materials, manufacturing, instrumentation, test, conditioning and shipping of hardware
- Risk Analysis, Failure Mode and Effect Analysis
- Demonstrated capability to deliver PGBs able to be integrated on an actual scale 1 Flying Test Bed

▪ **Capabilities and track records**

- Company qualified as an Aeronautic Supplier for Product Commercial Engine Parts
- Company certified for Quality regulations (ISO 9001, ISO 14001) and for Design of engine subsystems or modules (CSE, Part 21, Part 145).

▪ **Competences to deal with risks associated to the action**

At SPD level :

- Background in Research and Technology for aeronautics especially on Geared Turbofan Demonstrators and Gear System parts.
- Lessons learnt on achievements in the frame of former R&T European programs (FP7 or Clean Sky): delivery of instrumented part(s) or module(s) for scale one engine demonstrator experience on design ,manufacturing and testing of high power high density gear system and associated parts (PW=23 MW, weight 300 kg)

At applicant level:

- Background in Research and Technology for aeronautics
- Lessons learnt on former R&T European program (FP7 or Clean Sky)
- Project Management capability for 10M€ project
- Quality Management capability for 10M€ project
- Exchange of Technical Information through network: 3D models of parts, Interface Control Documents
- Digital Mock-Up
- 3D models available at CATIA format

- **Expertise**
 - Available in the internal audit team
 - Resources in house for design, manufacturing, material, instrumentation, tests
- Intellectual property and confidentiality
 - Snecma will own the specification, while the Core-Partner(s) will own the technical solutions that he will implement into the corresponding subsystems.
 - Snecma information related to this programme must remain within the Core-Partner(s); in particular, no divulgation of this topic to Core-Partner(s) affiliate will be granted.
- Ownership and use of the demonstrators
 - The Core-Partner(s) will deliver demonstrator parts to Snecma. Each part integrated or added in the demonstrator will remain the property of the party who has provided the part.
 - Notwithstanding any other provision, during the project and for five (5) years from the end of the project, each party agrees to grant to Snecma a free of charge right of use of the relevant demonstrator and its parts.
 - After the end of the period, each party may request the return of the parts of the demonstrator(s) that it provided. If the concerned parts are returned, no warranty shall be given or assumed (expressed or implied) of any kind in relation to such part whether in regard to the physical condition, serviceability, or otherwise.

4. Major deliverables and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type*	Due Date
D1	PGB module for UHPE GTD: Concept Study and Feasibility Report	R and RM	Q4 2015
D2	PGB for UHPE GTD: Demo Specifications	R and RM	Q3 2016
D3	PGB module for UHPE GTD: Preliminary Design Review and Report	R and RM	Q4 2017
D4	Design of PGB for UHPE GTD: Critical Design Review and Detailed Design Report	R and RM	Q4 2018
D5	Results of partial tests, material tests for technology maturation and assessment: Tests Report	R and RM	Q2 2018
D6	PGB module for UHPE GTD: rig tests plan and scale 1 rig Tests Readiness Review	R and RM	Q2 2019
D7	PGB module hardware delivery to rig test facility	D	Q3 2019
D8	PGB module: rig testing complete – completed with hardware inspection review and report.	RM	Q2 2020
D9	PGB: rig test reports	R	Q3 2020
D10	PGB module: hardware delivery to engine assembly stand	D	Q3 2019
D11	Engine readiness review Documentation for PGB module: -Delivered Hardware status -Instrumentation -Engine Test Plan requirements	R and RM	Q3 2020
D12	Lessons learnt for PGB module	R	Q3 2021

***Type:**

R: Report

RM: Review Meeting

D: Delivery of hardware/software



5. Schedule

2

[illegible]

III. Business Aviation / Short Regional TP demonstrator - Front Power Plant Module

Leader and Programme Area [SPD]	ENG		
Work Packages (to which it refers in the JTP)	WP3		
Indicative Topic Funding Value	6,5 M€		
Leading Company	TURBOMECA		
Duration of the action	48	Start Date	Q1/2015
Date of Issue	July 2014	Call Wave	1

Topic Number	Title		
JTI-CS2-2014-CPW01-ENG-01-03	Business Aviation / Short Regional TP demonstrator Front Power Plant Module	Duration	48
		Start Date	Q1/2015

Short description and terms of reference:

WP3 will concentrate on the design, development and ground testing of an Integrated Power Plant System (IPPS) demonstrator in the 1800-2000 HP THERMAL POWER class for business aviation and short range regional application.

1. Background

WP3 targets the acquisition of technologies for a high performance turboprop in the 1800-2000 shp class which will significantly upgrade the actual product efficiency. This demonstrator will deliver technologies maturity up to TRL 5/6 in 2019 with capability to be part of the next generation of aircrafts.

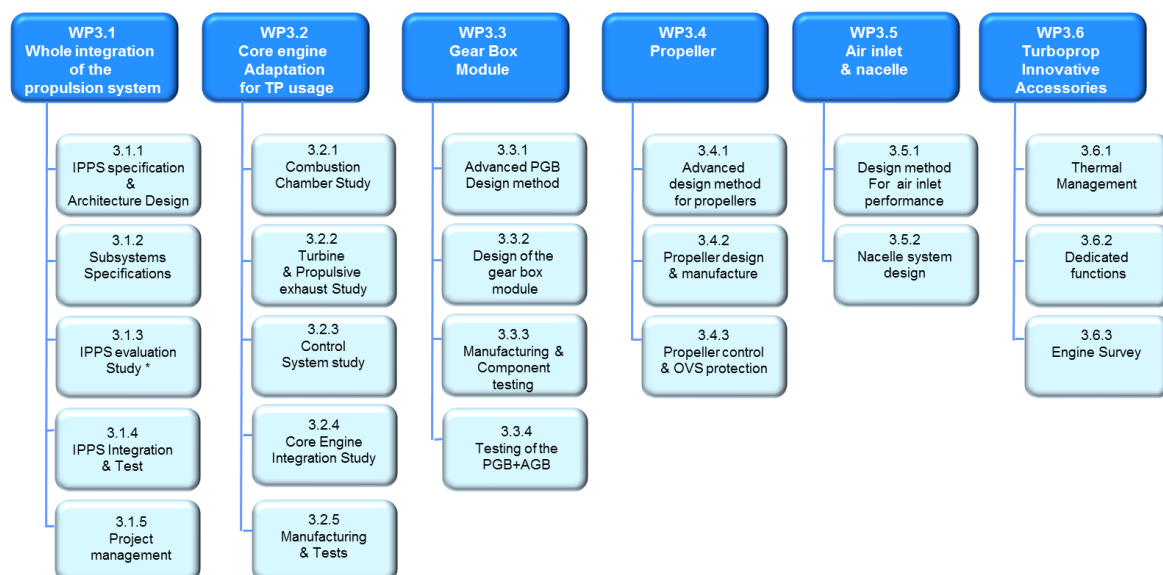
The purpose is to provide an alternative to US products with an optimized solution based on a whole Integrated Power Plant System; each Subsystem will be optimized taken into account the other subsystems and the overall target.

The current reference has 83% of market share in the considered power class.

The purpose is to bring to the market a new generation of turboprop; each subsystem of the turboprop is meant to become the new state-of-the-art to achieve a global improved solution.

The base line core of ARDIDEN3 engine will be improved specifically for turboprop application (combustion chamber, power turbine) and then integrated with innovative gear box, new air inlet and innovative propeller.

The figure belows shows the project structure. The Core-Partner(s) is (are) expected to lead the work packages WP3.3 & WP3.4 as well as the sub work package WP3.5.1. He will also take active part in the work package WP3.1, in particular in the elaboration of the specifications and the ground testing.



2. Scope of work

This call for Core-Partner(s) is (are) dedicated to the Front Power Plant Module (FPPM). The Core-Partner(s) will be responsible for the design, development and component testing of the following subsystems:

- Power & accessory gear box,
- Propeller and associated control system,

Those subsystems will be manufactured in quantities and scales suitable for the purpose of the ground testing to be performed at various test facilities.

The Core-Partner(s) will be responsible for delivering the Front Power Plant Module to be tested at TURBOMECA test facility.

In particular, as far as the Power and accessory Gear Box sub-system is concerned, the activity will mainly consist in:

- Participating to the elaboration of the technical specification for the PGB & AGB sub-system
- Designing the PGB & AGB sub-system (engine accessories are provided by TURBOMECA), under certification constraints, based on specification issued and owned by TURBOMECA
- Manufacturing 5 PGB & AGB sub-systems
- Delivering to TURBOMECA 2 PGB & AGB sub-systems to be tested at TURBOMECA test facility
- Supporting TURBOMECA testing
- Designing & Manufacturing a partial test rig for PGB & AGB
- Performing tests of the power line of the PGB & AGB sub-system (fatigue, endurance, vibration test) simulating aerodynamic effects of the propeller
- Performing technical reviews for the PGB & AGB sub-system, with TM participation

Main technical parameters of the PGB/AGB sub-system specification will be:

- 1000 HP typical maximum shaft horse power
- Typical Range of 1800 to 2000 RPM on the shaft
- Total weight of the PGB/AGB shall not exceed 50kg (dry)

As far as the Propeller sub-system is concerned, the activity will mainly consist in:

- Participating to the elaboration of the technical specification for the propeller module
- Designing the propeller and the actuation system including the overspeed system and addressing the case of synchrophasing
- Participating in the propeller conception iterative process with TM, using or developing an advanced project propeller design tool (capability for the tool to perform parameter studies on main propeller design parameters: # of blades, Diameter, Activity Factor, sweep, chord law, etc..)
- Providing Aerodynamic fields (air flow velocities, pressures and temperatures) downstream

of the propeller

- Providing a complete propeller performance deck for the overall aircraft and engine flight envelope.
- Providing to TM all the stress loads, due to propeller, on shaft: 1P and nP Loads, Gyroscopic, etc...
- Delivering a complete propeller
- Supporting TM during engine testing
- Performing technical reviews for the propeller module, with TM participation

Main technical parameters of the propeller module specification will be:

- 1000 maximum shaft horse power
- 1800 RPM < propeller rotationnal speed < 2000 RPM
- Weight below 80 kg
- 2.2m < propeller diameter < 2.4m
- 4 to 6 blades
- Typical hub diameter ~20 inch
- Activity factor: cruse oriented propeller
- Single acting propeller system
- Main positions: reverse position, flight idle, ground idle

The Core-Partner(s) will be responsible for:

- Performing Blade Element Method (BEM) analysis of propeller design using home made code
- Elaborating 3D mesh strategies for CFD simulations on propeller and on propeller + air intake
- Performing 3D CFD simulations and aerodynamics and acoustics analysis on propeller and on propeller + air intake for performance evaluation, including total pressure, angle and Mach number distortions in the inlet compressor plan, at 4 flight conditions (typically Max cruise, Long range, Max climb, Take off, to be defined during the project). Three levels of complexity will be considered int these simulations
 - Actuator disc (propeller considered as a boundary condition)
 - Moving Reference Frame (MRF) for both isolated propeller and propeller + air intake
 - Full 3D unsteady simulations
- Performing 3D analysis for detailed drag sources extraction of propeller & air intake (for example far field analysis), including nacelle effect
- Comparing CFD methods that will be applied, including:
 - Validation protocol for each CFD method (based on available database)
- Proposing design methodology combining CFD and low order method such as BEM
- Proposing guidance for aerodynamic & acoustic design improvement (for instance, pressure losses and distortion reduction)
- Refining BEM tools analysis based on 3D CFD results and/or on available database



Topics for Core-Partners Call 1



3. Special skills, capabilities - See list under Paragraph II

The technologies (Aerodynamic, Aeromechanical, Mechanical, Material, Manufacturing and Methods) required for supporting these modules demonstration will be assessed within these activities.

Among them, strong expertise in CFD simulations and analysis on aerodynamic & acoustic is required.

Expertise in designing, developing, building and testing the following subsystems, under EASA certification constraints, is mandatory:

- Power & accessory gear box module,
- Propeller & actuation system module (including OVS protection),

Expertise in performing URANS CFD simulations is required on the following topics:

- Isolated propeller
- Isolated air intake
- Interactions between propeller, air intake & nacelle.

The Core-Partner(s) will demonstrate to have recognized skills in aeronautics in:

- Aero-thermo-mechanics coupled phenomena
- Light weight propeller & power gear box design
- Module testing in relevant environment
- Acoustics
- Vibrations
- HPC CFD simulations
 - Aero-thermo-acoustics coupled phenomena
 - Aerodynamics and Acoustics
 - Air flow numerical simulations of propellers and unsteady interactions between propeller & engine air intake
- Experience of EASA certification process in the field of activity of this call (aero engine PGB&AGB and propeller)

Certification for propeller subsystem:

- ISO 9001,
- Part 145,
- Part 21

Equipments:

- Facilities for propeller demonstrator manufacturing
- Facilities for PGB/AGB manufacturing and testing
- Heavily instrumented test rigs for PGB & AGB module
- Numerical tools (Software + Hardware) & capacities for running HPC 3D CFD simulations
- Numerical tools (Software + Hardware) for design (CAD model to be exchanged)
- Description of the physical models and numerical methods that will be used

4. Intellectual property and confidentiality

TURBOMECA will own the specification, while the Core-Partner(s) will own the technical solutions that he will implement into the corresponding subsystems.

Any TURBOMECA information related to this programme must remain within the Core-Partner(s); in particular, no divulgation of this topic to Core-Partner affiliates will be granted.

5. Ownership and use of the demonstrators

The Core-Partner(s) will deliver demonstrator parts to TURBOMECA. Each part integrated or added in the demonstrator will remain the property of the party who has provided the part.

Notwithstanding any other provision, during the project and for five (5) years from the end of the project, each party agrees to grant to TURBOMECA a free of charge right of use of the relevant demonstrator and its parts.

After the end of the period, each party may request the return of the parts of the demonstrator(s) that it provided. If the concerned parts are returned, no warranty shall be given or assumed (expressed or implied) of any kind in relation to such part whether in regard to the physical condition, serviceability, or otherwise.

6. Definition of terms

AGB: Accessory Gear Box

BEM: Blade Element Method

CFD: Computational Fluid Dynamic

FPPM: Front Power Plant Module

HPC: High Performance Computing

HW: Hardware

IPPS: Integrated Power Plant System

OVS: Overspeed

7. Major deliverables and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type	Due Date
	WP3.3.2: Minutes of PGB & AGB PDR including - Explanations for selecting/discarding technical solutions - Trade study report	Doc	Q4/2015
	WP3.3.2: PGB & AGB 3D model, including interfaces and principles of design To be updated during the project	Doc + SW	Q4/2015
	WP3.3.2: Minutes of PGB & AGB CDR including - Explanations for selecting/discarding technical solutions - Final gear box geometry & CAD model (showing interfaces and principles of design)	Doc	Q3/2016
	WP3.3.2: Model for structural analysis of PGB&AGB casing and model of power shaft line for torsional analysis	SW	Q3/2016
	WP3.3.2: Thermal-hydraulic model of the PGB including load	SW	Q3/2016
	WP3.3.2: PGB & AGB Failure Mode Effect & Critical Analysis	Doc	Q4/2017
	WP3.3.2: PGB & AGB Safety analysis including Fault tree analysis	Doc	Q4/2017
	WP3.3.3: 5 PGB & AGB modules	HW	Q4/2017
	WP3.3.3: PGB & AGB power line test rig	HW	Q4/2017
	WP3.3.4: Test programme of PGB&AGB partial testing	Doc	Q2/2017

Deliverables			
Ref. No.	Title - Description	Type	Due Date
	WP3.3.4: Detailed Report of PGB&AGB partial testing including - Eventual incidents, problems - Test results analysis	Doc	Q4/2018
	WP3.3.4: Minutes of PGB & AGB TRL review	Doc	Q1/2019
	WP3.4.1: "Black box" propeller performance simulation tool allowing diameter etc. to be adjusted	Doc + SW	Q1/2015
	WP3.4.1: Minutes of propeller PDR including - Explanations for selecting/discarding technical solutions - Trade study report showing different blade geometries and associated performance	Doc	Q4/2015
	WP3.4.1: Minutes of propeller CDR including - Explanations for selecting/discarding technical solutions - Final blade outside geometry & CAD model (showing interfaces and principles of design)	Doc	Q3/2016
	WP3.4.2: Propeller concept scheme	Doc + SW	Q2/2016
	WP3.4.2: Description of propeller manufacturing process	Doc	Q2/2016
	WP3.4.3: A (static + dynamic) model of the isolated propeller (such as "black box") to be used by engine controls	SW	Q4/2015
	WP3.4.3: A (static + dynamic) model of the propeller controls (such as "black box") to be used by engine controls	SW	Q4/2015
	WP3.4.3: A complete propeller including controls & OVS protection system	HW	Q4/2017

Deliverables			
Ref. No.	Title - Description	Type	Due Date
	WP3.4.3: Propeller & controls Failure Mode Effect & Critical Analysis	Doc	Q4/2017
	WP3.4.3: Propeller & controls Safety analysis including Fault tree analysis	Doc	Q4/2017
	WP3.4.3: Propeller synthesis report including - Minutes of Propeller TRL review - Control system benefits study	Doc	Q4/2018
	WP3.5.1: BEM design tool	SW	Q2/2015
	WP3.5.2: Isolated Propeller: Detailed Report of 3D aerodynamic & acoustic simulations including analysis	Doc	Q2/2016
	WP3.5.2: IPPS (Propeller & air intake & nacelle): Detailed Report of 3D aerodynamic & acoustic simulations including analysis	Doc	Q4/2016
	WP3.5.2: Detailed Report with design guidance for IPPS performance improvement (aerodynamic, noise) & improved design methodology	Doc	Q2/2017

IV. Aerodynamic design and testing of advanced geared fan engine modules

Leader and Programme Area [SPD]	MTU Aero Engines AG - ENG		
Work Packages (to which it refers in the JTP)	Chap 10.7.4 a) WP4.1. / Chap 10.7.4 b) WP4.2. / Chap 10.7.4 f) WP4.6.		
Indicative Topic Funding Value	6 M€		
Leading Company	MTU Aero Engines AG		
Duration of the action	Approx. 6-7 yrs.	Start Date	Jan 2015
Date of Issue	09.07.2014	Call Wave	1

Topic Number	Title		
JTI-CS2-2014-CPW01-ENG-02-01	Aerodynamic design and testing of advanced geared fan engine modules	Duration	Approx. 6-7 yrs
		Start Date	Jan 2015

1. Background

The Sustainable and Green Engine ITD in Clean Sky addresses technologies for a wide range of applications including rotorcraft, regional, short range and long range aircraft. The ITD is organised in six projects, each focussed on technologies for a specific market sector.

SAGE4's technology programme is aimed for testing key enabling technologies as advanced materials including manufacturing processes in rig and engine demonstrator environment to prove the necessary technology level up to TRL6. In MTU's demonstrator the main activities are focused on technologies for HPC and LPT including adjacent components impacting the design and performance of the focused modules.

2. Scope of work

2.1 Proposed scope of work and activities outputs

It belongs to the declared goals of work package #4 "Advanced Geared Engine Configuration" to achieve a significant improvement of the overall propulsion system efficiency by an optimization approach that spans neighboring engine modules.

Concerning the compression system, this approach asks for a joint development effort for the low pressure compressor (LPC), the inter-compressor duct (ICD) and the high pressure compressor (HPC) in order to optimally synchronize the operation of those three components under all relevant engine conditions.

Based on a reference engine concept representing the next generation of geared fan engines, MTU intends to develop and validate together with its Core-Partner(s) technologies for an engine compression system with significantly improved operational performance parameters.

Compression System Development

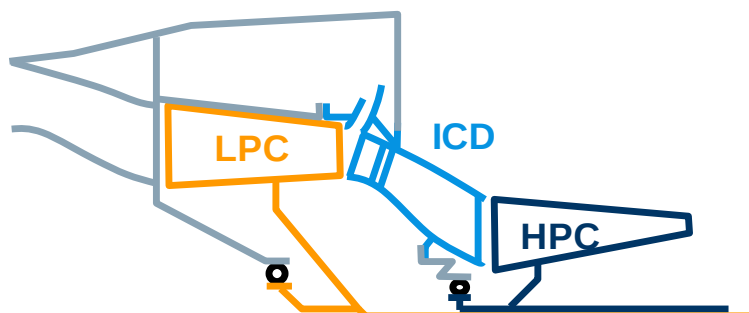


Fig. 1: Schematic view of the compression system

Fig. 1 shows a schematic view of the compression system under consideration. It consists of the LPC, the ICD, the HPC and a casing structure locating the three components together.

Overall Compression System Design (Topic Leader)

MTU will be in charge of the overall system design with respect to compressor performance, aerodynamics and rotor dynamics, as well as of the development of the HPC. In order to validate the integrally optimized compression system, MTU in close cooperation with its Core-Partner(s) plans to design and test a two-shaft compressor rig.

Parts of the cross-module, multi-physics simulation and optimization of the compression system, as well as the development and test of the compressor rig is proposed to competent Core-Partner(s).

The following Core-Partner tasks are related to WP4.1 and WP4.2:

Development of multidisciplinary Tools (Core-Partner(s))

- Development of simulation and optimization strategies for the geometry generation of compressor components under consideration of conflicting design objectives (e.g. aerodynamic efficiency, structural integrity, weight, erosion resistance ..)
- Implementation of the optimization strategy into a multi-physics simulation environment.

Design of Sub modules using multidisciplinary Tools (Core-Partner(s))

- Application of the methods and tools within the component and module design and optimization process for the notional engine as well as for the compressor rig.

The following Core-Partner tasks are related to WP4.6:

Testbed Design or adaptation and Testing (Core-Partner(s))

- Design and analytical substantiation (aerodynamics, structures) of the test bed for the different builds of the compressor rig.
- Procurement of all necessary testbed hardware for the different builds of the compressor rig (excluding the test objects provided by MTU or further project partners)
- Design and procurement of the test instrumentation and the data acquisition systems necessary for the technology validation
- Calibration of the testbed instrumentation
- Preparation and execution of the planned compressor rig tests

Analysis and evaluation of test results (Core-Partner(s))

- Evaluation of the compressor rig tests, comparison of the results with the predictions made by the simulation tools.
- Improvement of simulation and optimization strategies and tools based on the learnings from the first rig test.
- Application of the results in the second stage of the compressor design project.

2.2 Estimated total value of the topic

The total value of the topic is estimated with 12,0 M€ and corresponds to 6,0 M€ funding.

2.3 Reference to WBS

The Core-Partner(s) for this proposal shall participate in WP4.1 & WP4.2 and shall be responsible for testing of the compressor rig in WP4.6. Testing of Rigs and Engine Demonstrator (JTP Chap 10.7.4 f). WP4.1 and WP4.2 include technology development as well as the development of test hardware for the compression system required for technology validation.

WP4.6 consists of the technology development, development and provision of test enabling hardware, test execution and test evaluation for the compression system.

2.4 Expected overall contribution: output, timeframe, major deliverables

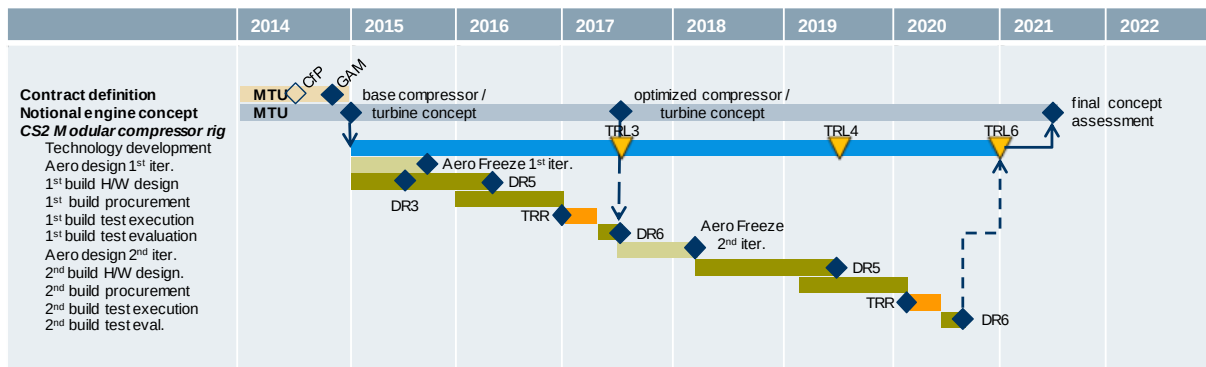


Fig. 2: Preliminary schedule of the technology development and the planned validation vehicles

Fig. 2 shows a preliminary time schedule of the technology development and the planned validation vehicle for the compression system within the Clean Sky 2 framework.

For the modular compressor rig two different rig builds and tests are planned. Based on the learning from build #1 an optimized compressor concept shall be developed and validated in compressor build #2. The results of the 2nd rig build are intended to achieve TRL 6 for the technologies developed by the partner companies. The major deliverables of this part of the task are defined as follows:

- Definition of a simulation and optimization strategy for compressor components and modules in close cooperation with the project leader based on the boundary conditions of the notional engine concept.
- Implementation and validation of the defined simulation tool modifications.
- Delivery of optimized component and module geometries within the multiple iterations of the compressor conceptual and detail design to the project leader or other partners.
- Design documentation (Design schemes, 3D models, drawings) for the 1st build of the compressor rig excluding the test hardware provided by topic leader or further partners
- Analytical substantiation (Structural Integrity, rotor dynamical stability, life, compliance with the validation targets) excluding the test hardware provided by topic leader or further partners

- Procurement of the hardware required for the 1st build of the compressor rig excluding the test hardware provided by topic leader or further partners
- Preparation of the testbed for the test execution (mechanical adaption of the test vehicle, installation of the necessary data acquisition systems, calibration of the test bed, ...)
- Installation of the test vehicle into the test cell and commissioning of the test setup
- Execution of the compressor test in close cooperation with the partners
- Evaluation of the acquired test data of build #1 and transfer to the partners
- Definition and implementation of method and tool improvements based on the learnings from the test applicable to the second phase of the project
- Design documentation (Design schemes, 3D models, drawings) for the 2nd build of the compressor rig excluding the test hardware provided by topic leader or further partners
- Analytical substantiation (Structural Integrity, rotor dynamical stability, life, compliance with the validation targets) excluding the test hardware provided by topic leader or further partners
- Procurement of the hardware required for the 2nd build of the compressor rig excluding the test hardware provided by topic leader or further partners
- Preparation of the testbed for the test execution (mechanical adaption of the test vehicle, installation of the necessary data acquisition systems, calibration of the test bed, ...)
- Installation of the test vehicle into the test cell and commissioning of the test setup
- Execution of the compressor test in close cooperation with partners
- Evaluation of the acquired test data of build #2 and transfer to partners
- Final validation of the developed multi-objective, multi-physics simulation and optimization framework

2.5 Short-medium term objectives / milestones

Objectives and milestones Compression System Development 2015-2016

Details of deliverables are given in “Major deliverables and schedules”. On a higher level, the following results are due in 2015 – 2016:

- Definition of the notional engine concept and the related requirement specification for the modular compressor rig
- Execution of concept studies for compression system components of the notional engine
- Design definition of the test enabling hardware for the first build of the compressor rig
- Provision of the test enabling hardware for the first build of the compressor rig
- Start of the compression system related technology developments

3. Special skills, capabilities

3.1 Competences

In order to safeguard the completion, technology insertion and success the overall validation vehicle the Core-Partner(s) have to provide substantial and essential contribution. Therefore the Core-Partner(s) need(s) to have the expertise and the technical means to fulfill the tasks outlined in chap. 1.

The Core-Partner(s) need(s) to feature the following competences:

- *Proven knowledge and experience in the aerodynamic design of compression system components* to perform the task of optimizing compression system modules with regard to their aerodynamic behavior as contribution to achieving a globally optimized compression system.
- *Expertise in applying and advancing of optimization methods and tools to support multi-disciplinary/multi-objective optimization.* This capability is needed to perform optimization of compression system components being subject to a number of optimization objectives the need to find an optimum configuration obeying design constraints resulting from non-aerodynamic considerations. Availability of the necessary numeric tools and computing power to perform the requested tasks.
- *Experience of running and evaluating cascade tests* as part of efforts to perform detailed experimental flow field investigations supporting a demand for enhanced knowledge of aerodynamic performance of blade rows. Availability of the required test facility.
- *Availability of proven expertise and experience in setting up and safely operating a two-spool compressor test facility (see Fig. 3).* This facility is a crucial element of the strategy to demonstrate the level of improvement to be expected from cross-module optimization of the various components of a compression system to achieve a global optimum. The facility needs to achieve Mach numbers and stage pressure ratios consistent with future product levels. Independent operation of the two spools is required in order to investigate behavior of the compression system and its components throughout the speed range of a future product application. Size of the test bed must be such to allow for installation of extensive measurement equipment. Capability to extract bleed flow from the gas path is required.

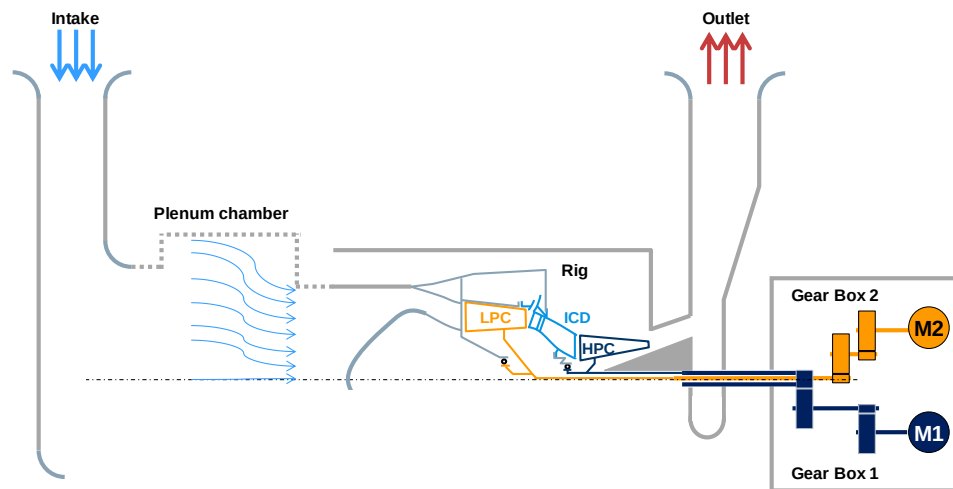


Fig. 3: Schematic sketch of the required test bed and the test set-up

- Translating of the aforementioned demands into quantitative requirements for the test bed yield

3.2 Requirements related to the operational capacity

An overall project organization has to be defined and established to enable efficient coordination of complex research activities whilst ensuring the integration of skills, resources, activities and objective-driven central project management to reach the targeted global project results.

A management structure has to be designed to reach the following objectives:

- Set up of a complete set of module requirements, to ensure unique interface definitions and design requirements. The requirements have to be jointly agreed.
- Ensure timely and qualitative achievement of the project objectives, including risk mitigation, recovery plans and quality control
- Coordinate the activities of the topic, if necessary at consortium level
- Provide decision making, quality control and conflict resolution mechanisms to support the project (consortium) and its evolution
- Support implementation of changes in the activities (and the consortium), including new entrants if and when needed
- Provide timely and efficient financial and administrative co-ordination of the project
- Support activities that need a strong coordination, for instance dissemination, innovation management, preparation for exploitation activities, or preparation of validation
- Coordinate and provide interfaces for conjunct action with the topic leader, other stakeholders and important decision makers for instance design reviews

3.3 Specific legal, IP, exploitation requirement and other issues

Legal, IP and exploitation requirements have to comply with the overall rules of CS2JU, defined in the ITD Consortium Agreement and the Model Grant Agreement.

3.4 Specific confidentiality and competitive issues and any specific requirement

Requirements concerning confidentiality and competitiveness have to comply with the overall rules of CS2JU, defined in the ITD Consortium Agreement and the Model Grant Agreement.

4. Major deliverables and schedule (estimate)

<i>Deliverables</i>			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type*</i>	<i>Due Date</i>
D1	Definition of a simulation and optimization strategy for compressor components and modules in close cooperation with the project leader based on the boundary conditions of the notional engine concept.	R	30.06.2015
D2	Substantiation of simulation tools • Implementation and validation of the defined simulation tool modifications. • Preparation of and participation in a method and tool verification review	P, R	31.12.2015
D3	Delivery of optimized component and module geometries within the multiple iterations of the compressor conceptual and detail design to the project leader or other partners.	O, R	2015 - 2019
D4	Preparation of and participation in development status meetings regularly organized by the project leader	R	2015-2021
D5	Conceptual Design Review DR3 • Exchange of aerodynamic and geometric data of the concept studies for LPC, ICD and bleed extraction • Conceptual design documentation for the 1st build of the compressor rig (Design schemes for the main elements of the test bed, 3D design scheme models) • Analytical substantiation of structural integrity, rotor dynamical stability, life, compliance with the validation targets	O	30.06.2015
D6	Critical Design Review DR5 – manufacturing release for the 1 st build of the compressor test bed • Detail design documentation for the first build of the compressor rig (Design schemes for all components of the test bed, 3D models, detail drawings) • Final analytical substantiation of structural integrity, rotor dynamical stability, reliability, compliance with the validation targets of the test enabling hardware (Substantiation reports) • Participation in the design review organized by the topic leader	R, O	31.03.2016

Deliverables			
Ref. No.	Title - Description	Type*	Due Date
D7	Test Readiness Review for 1 st build • Confirmation that the testbed and the test vehicle are ready for the defined test program • Proof that the defined test program can be safely executed • Confirmation that the test targets can be achieved • Participation in the test readiness review organized by the topic leader	D	31.12.2016
D8	Completion of testing of 1 st build of test vehicle	D	31.03.2017
D9	Post Test Review DR6 • Analysis report from 1st build test • Comparison between design intent and test data • Conclusions for the reference engine design and the 2nd build • Participation in the post test review organized by the topic leader	R	30.06.2017
D10	Substantiation of simulation tools • Definition and implementation of method and tool improvements based on the learnings from the test applicable to the second phase of the project • Preparation of and participation in a method and tool verification review	P, R	30.06.2018
D11	Critical Design Review DR5 – manufacturing release for the 2 nd build of the compressor test bed • Detail design documentation for the first build of the compressor rig (Design schemes for all components of the test bed, 3D models, detail drawings) • Final analytical substantiation of structural integrity, rotor dynamical stability, life, compliance with the validation targets (Substantiation reports) • Participation in the design review organized by the topic leader	R, O	30.06.2019

Deliverables			
Ref. No.	Title - Description	Type*	Due Date
D12	Test Readiness Review for 2 nd build • Confirmation that the testbed and the test vehicle are ready for the defined test program • Proof that the defined test program can be safely executed • Confirmation that the test targets can be achieved • Participation in the test readiness review organized by the topic leader	D	31.01.2020
D13	Completion of testing of 2 nd build of test vehicle	D	31.04.2020
D14	Post Test Review DR6 • Analysis report from 2nd build test • Comparison between design intent and test data • Conclusions for the reference engine design • Participation in the post test review organized by the topic leader	R	31.07.2020
D15	Final report	R	31.12.2020

*) R = Report; P = Prototype; D = Demonstrator; O = Other

V. LPC, ICD and TEC development for next generation geared fan engines

Leader and Programme Area [SPD]	MTU Aero Engines AG - ENG		
Work Packages (to which it refers in the JTP)	JTP Chap 10.7.4 a) WP4.1. JTP Chap 10.7.4 e) WP4.5.		
Indicative Topic Funding Value	7 M€		
Leading Company	MTU Aero Engines AG		
Duration of the action	Approx. 6-7 yrs.	Start Date	Jan 2015
Date of Issue	09.07.2014	Call Wave	1

Topic Number	Title		
JTI-CS2-2014-CPW01-ENG-02-02	LPC, ICD and TEC development for next generation geared fan engines	Duration	Approx. 6-7 yrs.
		Start Date	Jan 2015

1. Background

The Sustainable and Green Engine ITD in Clean Sky addresses technologies for a wide range of applications including rotorcraft, regional, short range and long range aircraft. The ITD is organised in six projects, each focussed on technologies for a specific market sector.

SAGE4's technology programme is aimed for testing key enabling technologies as advanced materials including manufacturing processes in rig and engine demonstrator environment to prove the necessary technology level up to TRL6. In MTU's demonstrator the main activities are focused on technologies for HPC and LPT including adjacent components impacting the design and performance of the focused modules.

2. Scope of work

2.1 Proposed scope of work and activities outputs

It belongs to the declared goals of work package #4 "Advanced Geared Engine Configuration" to achieve a significant improvement of the overall propulsion system efficiency by an optimization approach that spans neighboring engine modules.

Concerning the compression system, this approach asks for a joint development effort for the low pressure compressor (LPC), the inter-compressor duct (ICD) and the high pressure compressor (HPC) in order to optimally synchronize the operation of those three components under all relevant engine conditions.

The same applies for the engine exhaust system, where the high pressure turbine (HPT), the inter turbine duct (ITD), the low pressure turbine (LPT) and the turbine exit case (TEC) need to be combined to a harmonically interacting unit resulting in an overall efficiency optimum.

Based on a reference engine concept representing the next generation of geared fan engines, MTU, together with its Core-Partner(s), intends to develop and validate technologies for an engine compression system and an engine exhaust system with significantly improved operational performance parameters.

2.1.1 Compression System Development

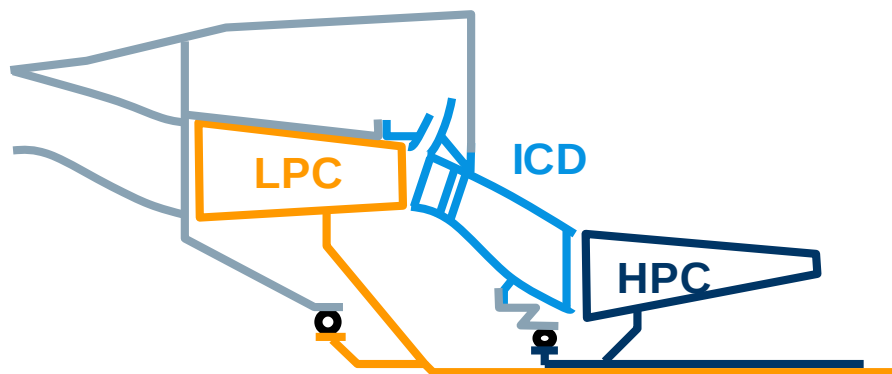


Fig. 4: Schematic view of the compression system

Fig. 1 shows a schematic view of the compression system under consideration. It consists of the LPC, the ICD, the HPC and a casing structure joining the three components together.

Overall Compression System Design (Topic Leader)

MTU will be in charge of the overall system design with respect to compressor performance, aerodynamics and rotor dynamics, as well as the development of the HPC. In order to validate the integrally optimized compression system, MTU in close cooperation with its Core-Partner(s) plans to design and test a two-shaft compressor rig consisting of the back-end of the LPC, the ICD and the front part of the HPC.

The following Core-Partner tasks are related to WP4.1.:

Development of ICD including LPC Backend (Core-Partner(s))

The development of the back end of the LPC, the ICD and the integrating case structure is therefore proposed to competent Core-Partner(s). This task includes the following elements:

- Participation in the generation of a module requirements document in close cooperation with the leader derived from the reference engine.
- Participation in concept studies for the LPC, the ICD and the bleed system in close

cooperation with the design lead in close cooperation with the compression system design lead.

- Integrated aerodynamic design of the back end of the LPC, the ICD and the bleed system based on the boundary conditions set by the compression system according to the agreed module requirements specification in close cooperation with the compression system design lead.
- Mechanical design of the back end of the LPC, the ICD with the bleed system and the casing structure based on the jointly chosen aerodynamic design.
- Structural optimization of the back end of the LPC, the ICD and the casing structure with respect to clearance optimization and system weight.
- Design and analytical substantiation (aerodynamics, structures) of the test hardware for the envisaged different builds of the compressor rig.
- Development of the materials and manufacturing technologies which are critical in order to meet the module system requirements of the compression system. Manufacturing of all necessary test hardware for the preparatory material and component tests as well as the validation tests on the compressor rig.
- Design and manufacturing of the test instrumentation essential for the technology validation
- Definition and execution of the necessary material and component validation tests in order to achieve TRL6 within the timeframe of the project.
- Engineering support of the preparation, execution and evaluation of the planned compressor rig tests

2.1.2 Expansion System Development

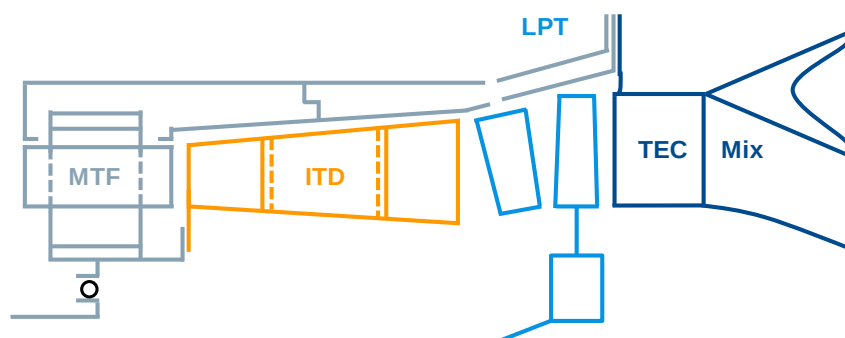


Fig. 5: Schematic view of the engine exhaust system

A schematic view of the engine expansion system is likewise shown in Fig. 5. It consists of the HPT, the ITD, the LPT and the TEC, as well as a mixer.

Overall Expansion System Design (Topic Leader)

MTU will take the responsibility for the overall system design with respect to turbine performance, aerodynamics and rotor dynamics, as well as the development of the ITD and the LPT. In order to validate the technologies for the integrally optimized engine expansion system, MTU plans to design and test an engine demonstrator in close cooperation with its Core-Partner(s). The choice of a turboshaft engine as a validation vehicle for the targeted expansion system technologies allows to reduce the complexity and the resources needed for achieving TRL 6.

The following Core-Partner tasks are related to WP4.5:

Development of Turbine Exit Casing and Mixer (Core-Partner(s))

The development of the TEC and the mixer are proposed to the Core-Partner(s). This task includes the following elements:

- Participation in the generation of a module requirements document in close cooperation with the leader derived from the reference engine.
- Integrated aerodynamic and acoustic design of the TEC and the mixer based on the boundary conditions set by the expansion and exhaust system of the reference engine according to the agreed module requirements specification in close cooperation with the expansion system design lead.
- Mechanical design of the TEC and the mixer based on the jointly chosen aerodynamic design
- Structural optimization of the TEC and the mixer with respect to clearance optimization and system weight.
- Design and analytical substantiation (aerodynamics, acoustics, structures) of the test hardware for the defined build of the engine demonstrator.
- Development of the materials and manufacturing technologies which are critical in order to meet the performance parameters of the TEC and the mixer set by the reference engine concept.
- Manufacturing of all necessary test hardware for the preparatory material and component tests as well as the validation tests on the engine demonstrator.
- Design and manufacturing of the test instrumentation essential for the technology validation
- Definition and execution of the necessary material and component validation tests in order to achieve TRL6 within the timeframe of the project.
- Engineering support of the preparation, execution and evaluation of the planned engine demonstrator test.

2.2 Estimated total value of the topic

The total value of the topic is estimated with 14,0 M€ and corresponds to 7,0 M€ funding.

2.3 Reference to WBS

The Core-Partner(s) for this proposal shall be responsible for the WP4.1. Compressor Intermediate Casing IMC (JTP Chap 10.7.4 a) and WP4.5. Turbine Exit Casing and Exhaust System (JTP Chap 10.7.4 e).

WP4.1 includes technology development as well as the development and the provision of test hardware for the IMC and the rear part of the LP compressor required for technology validation.

WP4.5 consists of the technology development, development and provision of test hardware for the Turbine Exit Casing and Exhaust System.

2.4 Expected overall contribution: output, timeframe, major deliverables

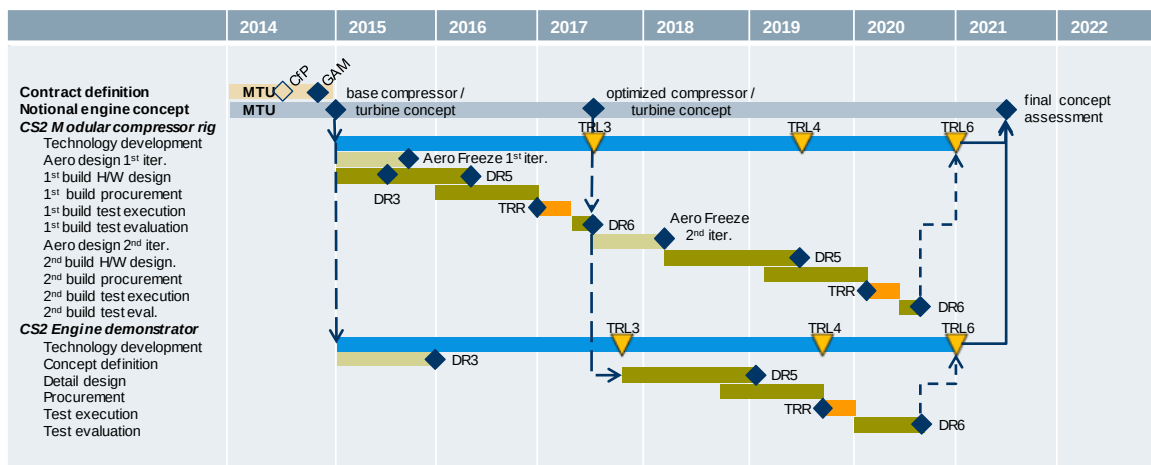


Fig. 6: Envisaged schedule of the technology development and the planned validation vehicles

Fig. 2 shows an envisaged time schedule of the technology development and the two planned validation vehicles within the Clean Sky 2 framework.

For the modular compressor rig two different rig builds and tests are planned. Based on the learning from build #1 an optimized compressor concept shall be developed and validated in compressor build #2. The results of the 2nd rig build are intended to achieve the TRL 6 for the technologies developed. The major deliverables of this part of the task are defined in the chapter “major deliverables”.

On the engine demonstrator side for the hot section, only one build is planned. An early concept phase shall assure that the demonstrator concept is feasible and that the validation requirements for the targeted technologies can be achieved during the demonstrator test. The detailed design phase will start after the technology projects have reached the necessary maturity level. The results of the demonstrator test are intended to achieve the TRL 6 for the technologies developed. The major deliverables of this part of the task are defined in the chapter “major deliverables”.

2.5 Short-medium term objectives / milestones

2.5.1 Objectives and milestones Compression System Development 2015-2016

Details of deliverables are given in “Major deliverables and Schedules”. On a higher level, the following results are due in 2015 – 2016:

- Definition of the notional engine concept and the related module requirement specifications
- Execution of concept studies for the ICD and LPC design of the notional engine
- Design definition for the first build of the for compressor rig
- Procurement of the hardware for the first build of the compressor rig
- Start of the ICD and LPC related technology developments

2.5.2 Objectives and Milestones Expansion System Development 2015-2016

Details of deliverables are given in “Major deliverables and Schedules”. On a higher level, the following results are due in 2015 – 2016:

- Definition of the notional engine concept and the related module requirement specifications
- Execution of concept studies for the exhaust system design of the notional engine
- Concept definition for the exhaust system of the engine demonstrator
- Start of the exhaust system related technology developments

3. Special skills, capabilities

3.1 Competences

In order to safeguard the completion, the technology insertion and the success of the overall validation vehicle the Core-Partner(s) has (have) to provide substantial and essential contribution. Therefore the Core-Partner(s) need(s) to own the necessary competences to fulfill the tasks designated to him, as outlined in chapter 1.

The Core-Partner(s) need(s) to feature the following competences:

- *Proven knowledge and experience in the development of ICD systems for turbofan engines (structural integrity and lifing, oil and air system, ...)* in order to assure that typical boundary conditions relevant for integration of an ICD into an engine are also considered during the design of intended test vehicle
- *Expertise in mechanical and structural design and optimization of the ICD*, considering system-related requirements in order to complete the assigned task of designing an ICD with improved aerodynamic properties with simultaneous consideration of necessary boundary conditions for future engine application.
- *Proven experience in manufacturing of ICD hardware to*
 - ensure the consideration of possible boundary conditions/constraints for the ICD design resulting from state-of-the-art manufacturing processes.
 - further develop manufacturing processes with the purpose to realize new design features promoting operational performance improvements (reduction of component losses, extension of component life, ...)
- *Proven expertise and experience in aerodynamic and aeromechanic design of compression system components* to perform the task of optimizing both LPC and ICD with regard to their aerodynamic behavior as contribution to a globally optimized compression system.
- *Proven expertise in designing and manufacturing of compressor blisks* in order to provide hardware for the planned test vehicle satisfying all requirements for safe operation.
- *Proven expertise in defining and conducting all required material and component tests* to demonstrate that the designed components fulfill the functional requirements for a safe test execution
- *Proven ability to design, manufacture and apply a suitable instrumentation* to validate compliance between design requirements and real hardware behavior. Validation is deemed necessary for aerodynamic purposes, but also to demonstrate that the designed components provide for fulfillment of structural integrity demands of a future engine application.

3.2 Requirements related to the operational capacity

An overall project organization has to be defined and established to enable efficient coordination of complex research activities whilst ensuring the integration of skills, resources, activities and objective-driven central project management to reach the targeted global project results.

A management structure has to be designed to reach the following objectives:

- Set up of a complete set of module requirements, to ensure unique interface definitions and design requirements. The requirements have to be jointly agreed.
- Ensure timely and qualitative achievement of the project objectives, including risk mitigation, recovery plans and quality control
- Coordinate the activities of the topic, if necessary at consortium level
- Provide decision making, quality control and conflict resolution mechanisms to support the project (consortium) and its evolution
- Support implementation of changes in the activities (and the consortium), including new entrants if and when needed
- Provide timely and efficient financial and administrative co-ordination of the project
- Support activities that need a strong coordination, for instance dissemination, innovation management, preparation for exploitation activities, or preparation of validation
- Coordinate and provide interfaces for conjunct action with the topic leader, other stakeholders and important decision makers for instance design reviews

3.3 Specific legal, IP, exploitation requirement and other issues

Legal, IP and exploitation requirements have to comply with the overall rules of CS2JU, defined in the ITD Consortium Agreement and the Model Grant Agreement.

3.4 Specific confidentiality and competitive issues and any specific requirement

Requirements concerning confidentiality and competitiveness have to comply with the overall rules of CS2JU, defined in the ITD Consortium Agreement and the Model Grant Agreement.

4. Major deliverables and schedule (estimate)

4.1 Compression System Development (Ref. Chap 2.1.1)

<i>Deliverables</i>			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type*</i>	<i>Due Date</i>
D1	Delivery of optimized component and module geometries within the multiple iterations of the compressor conceptual and detail design to the project leader or other partners.		2015-2019
D2	Conceptual Design Review DR3 • Exchange of aerodynamic and geometric data of the concept studies for LPC, ICD and bleed extraction • Conceptual design documentation for the 1st build of the compressor rig (Design schemes for the LPC back end, the ICD and the surrounding casing structure, 3D design scheme models) • Analytical substantiation of structural integrity, life and compliance with the validation targets • Participation in the design review organized by the topic leader	O	30.06.2015
D3	Aero design of an optimized ICD for the 1 st build of the test vehicle (aero freeze) • Design report • Completion of review between topic leader and Core-Partner(s) to show compliance with targets for first build • Prel. geometry release to partners	R, O	30.09.2015
D4	Aero design of optimized LPC stage for 1 st build of test vehicle (aero freeze) • Design report • Completion of review between topic leader and Core-Partner(s) to show compliance with targets for first build • Prel. geometry release to partners	R, O	30.09.2015

Deliverables			
Ref. No.	Title - Description	Type*	Due Date
D5	Critical Design Review DR5 – manufacturing release for the 1st build of the compressor test hardware (LPC, ICD and casing structure) - Detail design documentation for the first build of the compressor rig (Design schemes for all components, 3D models, detail drawings) - Final analytical substantiation of structural integrity, life, compliance with the validation targets (Substantiation reports) - Participation in the design review organized by the topic leader	R, O	31.05.2016
D6	Delivery of hardware for 1 st build of test vehicle	D	30.06.2016
D7	Post Test Review DR6 - Analysis report from 1st build test - Comparison between design intent and test data - Conclusions for the reference engine design and the 2nd build - Participation in the design review organized by the topic leader	R	30.06.2017
D8	Aero design of optimized LPC/ICD for 2nd build of test vehicle (aero freeze) - Design report - Completion of review between topic leader and Core-Partner(s) to show compliance with targets for first build - Prel. geometry release to partners	R, O	31.03.2018
D9	Critical Design Review DR5 – manufacturing release for the 2nd build of the compressor test hardware (LPC, ICD and casing structure) - Detail design documentation for the 2nd build of the compressor rig (Design schemes for all components, 3D models, detail drawings) - Final analytical substantiation of structural integrity, life, compliance with the validation targets (Substantiation reports) - Participation in the design review organized by the topic leader	R, O	30.06.2019

Deliverables			
Ref. No.	Title - Description	Type*	Due Date
D10	Finalization of the necessary material and component validation tests in order to achieve TRL6 within the timeframe of the project	R	30.06.2019
D11	Delivery of hardware for 2 nd build of test vehicle	D	30.06.2019
D12	Post Test Review DR6 • Analysis report from 2nd t build test • Comparison between design intent and test data • Conclusions for the reference engine design • Participation in the design review organized by the topic leader	R	31.07.2020
D13	Final report	R	31.12.2020

*) R = Report; P = Prototype; D = Demonstrator; O = Other

4.2 Expansion System Development (Ref. Chap 2.1.2)

Deliverables			
Ref. No.	Title - Description	Type*	Due Date
	Delivery of optimized component geometries within the multiple iterations of the expansion system conceptual and detail design to the project leader or other partners.		2015-2019
D4.5.1	Conceptual Design Review DR3 • Exchange of aerodynamic and geometric data of the concept studies for TEC and mixer • Conceptual design documentation for the engine demonstrator (Design schemes for the TEC and mixer, 3D design scheme models) • Analytical substantiation of structural integrity, life and compliance with the validation targets • Participation in the design review organized by the topic leader	O	31.12.2015

Deliverables			
Ref. No.	Title - Description	Type*	Due Date
D4.5.2	Aero design of an optimized TEC and mixer for the demonstrator engine (aero freeze) • Design report • Completion of review between topic leader and Core-Partner(s) to show compliance with targets for first build • Prel. geometry release to partners	R, O	31.12.2017
D4.5.3	Critical Design Review DR5 – manufacturing release for the engine demonstrator test hardware (TEC and mixer) • Detail design documentation for the engine demonstrator (Design schemes for all components, 3D models, detail drawings) • Final analytical substantiation of structural integrity, life, compliance with the validation targets (Substantiation reports) • Participation in the design review organized by the topic leader	R, O	30.09.2018
D4.5.4	Finalization of the necessary material and component validation tests in order to achieve TRL6 within the timeframe of the project	R	31.03.2019
D4.5.5	Delivery of hardware for the engine demonstrator	D	31.03.2019
D4.5.6	Post Test Review DR6 • Analysis report for the demonstrator test • Comparison between design intent and test data • Conclusions for the reference engine design • Participation in the design review organized by the topic leader	R	30.06.2020
D4.5.7	Final report	R	31.12.2020

*) R = Report; P = Prototype; D = Demonstrator; O = Other

VI. VHBR Engine - IP Turbine Technology

Leader and Programme Area [SPD]	ENG		
Work Packages (to which it refers in the JTP)	WP5.2, WP6.1		
Indicative Topic Funding Value	20 M€		
Leading Company	Rolls-Royce Plc		
Duration of the action	5 years	Start Date	01/01/2015
Date of Issue	09 July 2014	Call Wave	1

Topic Number	Title		
JTI-CS2-2014-CPW01-ENG-03-01	VHBR Engine - IP Turbine Technology	Duration	5 years
		Start Date	01/01/2015

Short description and terms of reference

Through Clean Sky 2, Rolls-Royce are developing and demonstrating the complete range of technologies required for Very High Bypass Ratio engines. Key to this is the development of multi-stage intermediate pressure turbine (IPT) technology which forms the subject of this call.

The work intended to be covered by the Core-Partner(s) selected will be twofold; developing and demonstrating various individual technologies required to arrive at a competitive IPT module for a range of market applications, and delivering entire IPT modules for the demonstrator engine builds planned to run in this Programme.

The successful Core-Partner(s) will demonstrate both the capability to deliver cutting edge technology based on established track records of innovation, test facility capability and availability, as well as a proven and established capability for the delivery of entire and flightworthy modules for large scale aerospace gas turbine engine demonstrators. This implies demonstration of strong evidence of existing design and manufacturing capabilities, demonstrated readiness of the corresponding supply chain and the internal capacity to deliver in the timescales required, as well as experience with EASA flight clearance aspects in order to deliver world-class IPT technology for Rolls-Royce as an outcome of the joint work within Clean Sky 2.

1. Background

Through Clean Sky 2, Rolls-Royce are developing and demonstrating the complete range of technologies required for Very High Bypass Ratio engines.

Within the timescales of Clean Sky 2, Very high bypass ratio engines will realise significant environmental benefits:-

- Up to 25% fuel burn and CO₂ emission reduction relative to year 2000 baseline (consistent with 10% reduction relative to year 2014 baseline)
- Noise levels making a significant step towards to ACARE 2035 targets (- 11 EPNdB per operation relative to 2000 situation: including engine, nacelle, aircraft technologies - airframe noise reduction, novel aircraft configurations – and ATM benefits)
- Contribute to delivery of NO_x emission reductions through reduced fuel burn. Specific objectives will not be defined owing to the strong dependency on overall core engine cycle decisions.

Development of VHBR technology will also maintain European competitiveness in the development and integration of engines for Middle of Market short range commercial aircraft, to ensure capability across the full range of technologies required by geared engines, and develop a world-leading European capability for Very High Bypass Ratio engines for the large aircraft market, establishing a lead in this emerging market.

Two work packages are detailed within the joint technical proposal:-

Work Package 5 – VHBR – Middle of Market Technology

Throughout the course of the programme, work package 5 will demonstrate a range of underlying technologies necessary for very high bypass ratio (VHBR) engines in all markets, although focusing on Middle of Market short range aircraft. A series of design studies and rig tests will deliver TRL4-5 for each technology by 2018.

Work Package 6 – VHBR – Large Turbofan Demonstrator

Work package 6 targets the extension of Very High Bypass Ratio technologies to large engines for the long range airliner market. Building on the technology validation delivered by WP5, the project will develop these for higher power engines and ultimately demonstrate the technology at full system level in ground and flight test in order to achieve TRL 6 in 2019 in preparation for the next generation of wide body airliners.

Key to both work packages is the development of multi-stage, intermediate pressure turbine

technology which forms the subject of this call.

The intermediate turbine expands the working fluid provided to it by the up-stream higher-pressure turbine stage, converting the energy stored into kinetic energy which in turn is used to drive one or more compressor stages at the inlet of the engine. The IP turbine is an essential part of the Rolls-Royce turbofan and its development is critical to the success of the VHBR engine.

Within the Joint Technical Proposal, Work package 5.2 specifies the technology development required, and work package 6.1 integrates the multi-stage IP turbine with other key parts of the wider intermediate-pressure system to form a full system demonstrator.

2. Scope of work

The further advancement of multi-stage intermediate-pressure turbine (IPT) technology is a key enabler for the VHBR engine concept. This development comes with significant differences compared to conventional IPT concepts and presents significant technical challenges. Therefore, it will be essential to adopt a very clear and structured approach on this technology leap and to define the appropriate risk mitigation strategies as well as joint technology acquisition approaches required in order to industrialise this technology package.

The over-arching theme of the work scope and the topics below is to arrive at an aerodynamic, aeromechanical component and sub-system design for intermediate pressure turbines optimized for multi-stage operation. The optimised sub-system solution is to be found considering structural effects of more than one or two stages, maximising turbine efficiency within a compact structure, validation of overall performance and structural integrity, and thereby maximising benefits for all technical accounts like minimum SFC, minimum noise, reduced weight and cost.

The subsystem technology and design may be ultimately deployed in a number of engine markets and therefore scalability between middle-of-market and large civil applications is essential.

In order to be able to deliver a successful program, two major work packages have been identified: WP5.2 for Technologies for IPTs, and WP6.1.1 on IPT Demonstrator Modules.

At the beginning of this joint work with Rolls-Royce, and as part of WP6.1.1, the design space needs to be actively explored with the Core-Partner(s) in order to provide an optimised solution. This early phase of the work needs to be pursued very closely with Rolls-Royce in order to arrive at a jointly agreed architecture, including various options for the Fan and Compression side of the Intermediate-Pressure spool. Examples of such studies will likely include, but not be limited to:

- Turbine annulus studies - including number of stages, speed, and other parameters – in order to assess weight/cost/performance trades;

- Assessment of off-design operating conditions including turbine maps, Reynolds correction, tip clearance correction, and others;
- Non-conventional inter-stage structural and aerodynamic solutions;
- Aero/mechanically optimised 3D geometry design;
- Revisiting of conventional noise criteria.

Based on the completed multi-disciplinary optimization study above, the successful Core-Partner(s) will then be required to work very closely with Rolls-Royce on the specific aspects listed below.

WP5.2: Technologies for IPTs

1. Aerodynamic Design and Testing
2. Aeromechanical Assessment
3. Material evaluation and development
4. Methods development
5. Noise management technologies

WP6.1.1: IPT Demonstrator Modules

1. Sub-System Aspects and Analyses
2. Module Integration
3. Manufacturing of Demonstrator Module parts
4. Instrumentation of Demonstrator Module hardware
5. Support for Module flight clearance
6. Demonstrator Module delivery
7. Test Data Analyses

For both work packages, the following way of working together is envisaged: It is required that the Core-Partner(s) will lead both work packages and will work independently on all tasks whilst providing Rolls-Royce with clear visibility and insight into progress made and the results achieved. The agreement of suitable reviews with Rolls-Royce to buy-off technical concepts will be important to ensure the compatibility of the IPT module with the other parts of the engine. The following paragraphs describe more detail of the individual parts of both work packages.

WP5.2: Technologies for IPTs

Task 1: The **Aerodynamic Design and Testing** will have to be based on the material properties developed within Task 3 and the design rules derived from Task 2. The key challenges, including concepts of over-tip leakage management in this challenging low Reynolds and high Mach number environment, will have to be addressed through experimental testing at various levels of complexity, expected to range from cascade tests to multi-stage rig tests. More detailed assessments of the following aerodynamic challenges are anticipated and will require careful design considerations:

- Feasibility of design point efficiency level;
- Turbine characteristics at part-load and off-design conditions;
- Reynolds lapse rate and combined effect of high Mach and low Reynolds numbers;
- Detailed understanding of profile pressure distributions, stage work-split and reactions;
- Identification and assessment of areas for potential improvements;
- Non-conventional aerofoil shapes with high area-tapering and partial shroud;

- Verification and validation of the analysis/design tools outside the standard application ranges.

Task 2: The **Aeromechanical Testing** will have to focus on the development of design rules for the use of a yet not fully characterised material for the rear stages of the IPT, on new concepts for blade shrouds and blade lifing as well as on the stress assessment and lifing methods for the disc concepts.

From a mechanical point of view, the design will require addressing a number of challenges particularly associated to the high-temperature conditions in the front stages of the IPT turbines and high-stress levels and gas-loads in the rear stages. Optimisation of local design features and appropriate selection of materials will be critical to achieve a feasible mechanical design. Examples of such challenges will likely include, but not be limited to:

- Identification of materials requirements for high-temperature entry stages;
- Cooling design and lifing assessment;
- Understanding and definition of mechanical limits and design criteria (including novel low-weight materials);
- Assessment of blade stability and vibrational behaviour;
- Optimisation of local design features including shroud interlocks, fir-tree, and others;
- Novel concepts for disc and drum design and identification of material requirements.

Task 3: The **Material evaluation and development** will include a significant amount of work towards the evaluation of existing disc, casing, shroud, vane and blade materials for use in this high speed and temperature environment of an IPT. An extended work scope towards developing new material and manufacturing capability might have to be addressed depending on the outcome of the evaluation of existing materials.

Task 4: The advancement of **Methods Development** is required as well, in particular when it comes to the development of validated tools for forced response and prediction of resulting blade stresses.

Task 5: Lastly, the aerodynamic concepts for an IPT are likely to result in the need for new **Noise Management Technology** in order to arrive at competitive overall engine noise levels. Achieving the noise target for the increasingly more stringent regulations and airlines expectations presents challenges, which are anticipated to be particularly important for the IPT design. Examples of such challenges include:

- Increased blade frequency compared to conventional turbines which could be not high enough at particular flight conditions to achieve high tone frequency but at the same time is not low enough to use a reverse cut-off strategy.
- Requirement to cope with tight mechanical constraints which will primarily drive the choice of the number of blades.
- Potential impact of the structural first vane into the downstream blade rows.

A feasible design will likely require the introduction of novel low-noise technologies, which will need to be designed and validated as part of this work-package. In here, both concept and experimental work is planned.

WP6.1.1: IPT Demonstrator Modules

One of the fundamental elements to be demonstrated on the full-scale engine demonstrators in this work package is the complete integrated intermediate pressure system for a large high power, very high bypass ratio engine. The IP system will be heavily influenced by the whole engine architectural decisions, but it is likely that the design will be taken and developed from other technologies within Work Package 6.1 in CleanSky 2 targeting delivery of a low speed fan system with blades optimised to low pressure ratio duty and operation within in a nacelle environment with either variable area nozzle (VAN) or a variable pitch fan for operability control. Work Package 6.1.1 will cover the specific design work conducted for the IPT demonstrator module, the manufacture of full scale engine hardware as well as the support required for the flight clearance of the entire module. Hence it is expected that the Core-Partner(s) will provide hardware for the engine demonstrators. Focusing onto the delivery of the IPT Module, the major part of the work will have to focus on the implementation of the following aspects:

Task 1 Sub-System Aspects and Analyses: The work to be done in this task is going to be essential for the definition of the majority of the requirements driving the other activities in both WP5.2 and WP6.1.1 of the IPT program. In addition to standard tasks related to Sub-System analyses work, the following specific aspects are to be addressed here:

- Optimised aerodynamic, aerothermal and structural interfaces with surrounding architecture;
- Advanced inter-stage sealing;
- Implementation of noise reduction technology;
- Structure and bearing load management optimisation.

Task 2 Module Integration: This task will be essential to deliver an IPT module with competitive performance and ready to be smoothly integrated into the demonstrator engines. Due to the large exchange rate of performance to SFC for this application, the integration of enhanced active tip clearance control is the target and all relevant specific technologies required and interfaces to the whole engine concerned are to be addressed in here. There will be a strong overlap with Rolls-Royce work as interfaces to Turbines, Controls, Fluid Systems, Casings and Structures, Transmissions and Nacelles are affected, but the maintenance of all interfaces directly relevant to and part of the IPT module are going to be the responsibility of the designated Core-Partner(s). In addition to the integration of advanced tip clearance control aspects, the following aspects will have to be addressed in cooperation with RR:

- Overspeed protection;
- Whole Engine Modelling aspects;
- Air system and heat management
- Engine health monitoring and controls.

The responsibility for the HP/IP Structure will reside with Rolls-Royce.

Task 3 Manufacturing of Demonstrator Module Parts: Apart from manufacturing and delivering all parts required for the assembly of the IPT Module in Task 6, particular emphasis is to be made to the likely situation of requiring capability to manufacture parts using new materials, e.g. increased temperature disc and blade alloys, as well as for implementing simplified design styles in order to reduce part numbers for improved reliability and longevity of the parts.

Task 4 Instrumentation of Demonstrator Module Hardware: The specific instrumentation requirements are yet to be defined in the course of the program, but as part of the ground and flight test demonstrators planned, the design and application of both standard and special instrumentation will be required to ensure sufficient data is acquired to verify all aspects of the technology development. This list of instrumentation required is likely to include Performance and Air-System surveys, blade vibration measurements, TGT and tip clearance measurements, temperature measurements to verify aeromechanical models and others.

Task 5 Support for Module flight clearance: The Core-Partner(s) will be responsible for producing all relevant documentation required to obtain flight clearance for the flight test demonstrator Module.

Task 6 Demonstrator Module Delivery: The Core-Partner(s) will be responsible for all aspects relevant for the delivery of the IPT Modules for the three Demonstrator engines (two ground test engines and one flight test engine), these will comprise of, but will not be limited to, thermal as well as structural movements and the tail bearing housing (TBH). Obviously, the ultimate responsibility of the Core-Partner(s) will be the assembly and timely delivery of the IPT modules to the build-line of the engine according to Rolls-Royce quality standards.

Task 7 Test Data Analyses: The Core-Partner(s) will be responsible for post-processing all test data and for capturing relevant information, and eventually for the delivery of technical reports to Rolls-Royce as agreed in due course.

3. Special skills, capabilities

The unique skills expected from the successful applicant(s) are related to both aspects of the abovementioned overall programme, hence the technology development and the delivery of the Demonstrator modules. Therefore, the following areas of expertise would have to be responded to by the candidate:

WP5.2: Technologies for IPTs

Task 1 Aerodynamic Design and Testing: Based on the description of work detailed in Section 2, the Core-Partner(s) will be required to have significant experience in the aerodynamic design of an IPT for different types of applications. This will also include demonstrated capability to use high-fidelity analysis and design tools to optimise the aerodynamics of an IPT sub-system for real engine configurations. Extensive and demonstrated validation of such tools through 2D linear and 3D annular cascades and 3D multi-stage rigs is therefore critical. The Core-Partner(s) will therefore be required to have both significant and demonstrated previous experience in managing and delivering complex aerodynamic rig test programs as well as access to suitable facilities in support of this program.

Task 2 Aeromechanical Testing: Based on the description of work detailed in Section 2, the Core-Partner(s) will be required to have significant experience in the aeromechanical design and lifing of IPT components for different types of applications, including cooled components (either IPT stages for a 3-shaft engine or the first LPT stages of a 2-shaft application). Moreover, demonstrated experience in aeromechanical test programs as well as access to suitable facilities in support of this program are essential.

Task 3 Material evaluation and development: Based on the description of work detailed in Section 2, the Core-Partner(s) will be required to have significant experience in the fields of material characterisation, further development of materials for improved capabilities, and lastly, the integration of new materials into OEM procedures.

Task 4 Methods Development: Based on the general description of work detailed in Section 2, the Core-Partner(s) will be required to demonstrate a methods and tool set validated and fit for purpose for the work in this work package. Demonstrated experience in applying the methods and tool set for relevant applications would be essential.

Task 5 Noise Management Technology: Based on the description of work detailed in Section 2, the Core-Partner(s) will be required to demonstrate existing experience with regards to developing noise reduction technologies and measuring relevant experimental aspects of those as well as access to respective suitable test facilities.

WP6.1.1: IPT Demonstrator Modules

Task 1 Sub-System Aspects and Analyses: Based on the description of work detailed in Section 2, the Core-Partner(s) will be required to have significant and demonstrated experience in the field of Sub-System assessments relevant for the application in this program.

Task 2 Module Integration: Based on the description of work detailed in Section 2, the Core-Partner(s) will be required to have significant experience in managing complex interfaces to the relevant other parts of the engine and proven successful track record in working together with an OEM within development programs.

Task 3 Manufacturing of Demonstrator Module Parts: Based on the description of work detailed in Section 2, the Core-Partner(s) will be required to have significant experience in the fields of material characterization, further development of materials for improved capabilities, and lastly, the integration of new materials into OEM procedures (refer to Task 3 of WP5.2). Also, the Core-Partner(s) need(s) to demonstrate access to an established and competitive Supply Chain, to demonstrate experience in defining and validating manufacturing methods suitable for certified products that can meet Rolls-Royce quality standards as well as the capability to develop new manufacturing capability, e.g. Direct Laser Deposition for weight savings in static parts.

Task 4 Instrumentation of Demonstrator Module Hardware: Based on the description of work detailed in Section 2, the Core-Partner(s) will be required to have significant experience in the instrumentation design and integration into real engine environments. Any direct and internal experience of how to design suitable instrumentation would be beneficial.

Task 5 Flight Clearance of IPT Module: Based on the description of work detailed in Section 2, the Core-Partner(s) will be required to have significant experience with producing all relevant documentation required to obtain flight clearance for the demonstrator engine module.

Task 5 IPT Demonstrator Module Delivery: Based on the description of work detailed in Section 2, the Core-Partner(s) will be required to have significant experience in the full IPT Module assembly and a demonstrated record of successful program deliveries. Demonstrated OEM capability for this aspect will be essential.

Task 6 Test Data Analyses: Based on the description of work detailed in Section 2, the Core-Partner(s) will be required to have significant and demonstrated experience in post-processing and analysing significant amounts of data from real engine tests.

In addition to the specific list of required skills, certification and equipment mentioned above in the task descriptions for WP5.2 and WP6.1.1, **other generic requirements** to the successful Core-Partner(s) are listed below:

- Capability and demonstrated experience in working together with Academic Partners across Europe outside and/or within other European research programs;

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- Methods and tool set that is compatible with the Rolls-Royce system, in particular related to the CAD system;
- For all tasks, the appropriate levels of Programme and Risk Managements are to be implemented and to pursued;
- Demonstrated service experience of relevant products in order to optimise and deliver the best possible and robust product in terms of technical accounts, cyclic life capability and maintenance would be essential.

4. Major deliverables and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type	Due Date
5.2.1.1	Rig Test Strategy Approval	M	Q2/2015
5.2.1.2	Concept Review for Aerodynamic Rig	M	Q3/2015
5.2.1.3	Preliminary Design Review for Aerodynamic Rig	M	Q1/2016
5.2.1.4	Start of Test Campaign	M	Q1/2017
5.2.1.5	Completion of Test Campaign	M	Q3/2017
5.2.1.6	TRL6 Review with overview of final results	M	Q4/2017
5.2.2	Design rules for light weight blade material	D	Q1/2016
5.2.3	Optimised aeromechanical concept for cut-back shroud	D	Q1/2016
5.2.4	Life capability assessment of disc architecture	D	Q2/2016
5.2.5	Assessment of DLD for IPT Components	D	Q2/2015
5.2.6	Assessment of forced response behaviour of all blade rows	D	Q4/2016
5.2.7	Strategy for Noise Reduction in multi-stage IPT	D	Q2/2015
5.2.8	Test results from Noise Reduction experiments	D	Q4/2016
6.1.1.1.1	Optimised aerodynamic, aerothermal and structural interfaces available	D	Q1/2016
6.1.1.1.2	Concept for optimised interstage cavity completed	D	Q2/2016
6.1.1.1.3	Concept Review for Demonstrator Modules	M	Q3/2016
6.1.1.1.4	Preliminary Design Review	M	Q1/2017
6.1.1.1.5	Critical Design Review	M	Q4/2017
6.1.1.2.1	Module Interface Definitions agreed with RR	D	Q2/2015
6.1.1.2.2	Concepts for integration of TCC, Overspeed Protection, WEM, SAS and EHM agreed with RR	M	Q4/2015
6.1.1.3.1	Agreed workscope for incorporating new materials and methods of Manufacturing	D	Q2/2015
6.1.1.3.2	Release of forging definition for discs	M	Q3/2015
6.1.1.3.3	Casting definition of Vanes, blades and segments	M	Q4/2016

Topics for Core-Partners Call 1



Deliverables			
Ref. No.	Title - Description	Type	Due Date
6.1.1.3.4	Machining definition release for discs	M	Q4/2016
6.1.1.3.5	Machining definition release for vanes, blades and segments	M	Q1/2017
6.1.1.3.6	FPS for all Demonstrator Parts	M	Q3/2017
6.1.1.4.1	Definition of requirements for experiments and instrumentation	D	Q2/2016
6.1.1.4.2	Instrumentation Schemes ready	M	Q4/2016
6.1.1.4.3	FPS of all instrumented parts	M	Q4/2017
6.1.1.5.1	Agreement of Flight Clearance Requirements	M	Q2/2017
6.1.1.5.2	Provide Flight Clearance Documentation as required to RR	M	Q4/2017
6.1.1.6.1	FPS of Groundtest Module 1	M	Q1/2018
6.1.1.6.2	FPS of Groundtest Module 2	M	Q1/2018
6.1.1.6.3	FPS of Flighttest Module 3	M	Q3/2018
6.1.1.7.1	Test Schedule agreed for all 3 Demonstrator Builds	M	Q2/2018
6.1.1.7.2	Test Data Analyses for Groundtest 1	M	Q4/2018
6.1.1.7.3	Test Data Analyses for Groundtest 2	M	Q2/2019
6.1.1.7.4	Test Data Analyses for Flight test 1	M	Q4/2019

VII. VHBR Engine – Structural Technology

Leader and Programme Area [SPD]	ENG		
Work Packages (to which it refers in the JTP)	WP 5.1, 6.1		
Indicative Topic Funding Value	5 M€		
Leading Company	Rolls-Royce Plc		
Duration of the action	5 years	Start Date	01/01/2015
Date of Issue	09 July 2014	Call Wave	1

Topic Number	Title		
JTI-CS2-2014-CPW01-ENG-03-02	VHBR Engine – Structural Technology	Duration	5 years
		Start Date	01/01/2015

Short description and terms of reference

Through Clean Sky 2, Rolls-Royce are developing and demonstrating the complete range of technologies required for Very High Bypass Ratio (VHBR) engines. Key to this is the development of structural technology which forms the subject of this topic description.

Rolls-Royce are seeking Core-Partner(s) of a strategic nature within this field, willing and able to work together with us over the full duration of Clean Sky 2; a minimum of 5 years to delivery of the VHBR engine flight demonstration in 2019, with an extension into the post-demo analysis and improvement phase for the remaining programme.

The work initially intended to be covered by the Core-Partner(s) selected will be the research, design, validation and fabrication of novel fully integrated compressor intercase assemblies using advanced manufacturing techniques and optimized for weight, cost and compressor efficiency, for VHBR engine ground and flight test.

In addition to the scope of work defined herein, the Core-Partner(s) will be required to maximize their contribution to the programme by providing compelling proposals for additional technology or manufacturing development in the area of structural systems which will contribute to the improvement (in weight, efficiency, life, noise, environmental impact, cost or lead-time) of future very high bypass ratio gas turbine engines. To this end, there is some flexibility in the estimated topic value.

1. Background

Through Clean Sky 2, Rolls-Royce are developing and demonstrating the complete range of technologies required for Very High Bypass Ratio engines.

Within the timescales of Clean Sky 2, Very high bypass ratio engines will realise significant environmental benefits:-

- Up to 25% fuel burn and CO₂ emission reduction relative to year 2000 baseline (consistent with 10% reduction relative to year 2014 baseline)
- Noise levels making a significant step towards to ACARE 2035 targets (- 11 EPNdB per operation relative to 2000 situation: including engine, nacelle, aircraft technologies - airframe noise reduction, novel aircraft configurations – and ATM benefits)
- Contribute to delivery of NO_x emission reductions through reduced fuel burn. Specific objectives will not be defined owing to the strong dependency on overall core engine cycle decisions.

Development of VHBR technology will also maintain European competitiveness in the development and integration of engines for Middle of Market short range commercial aircraft, to ensure capability across the full range of technologies required by geared engines, and develop a world-leading European capability for Very High Bypass Ratio engines for the large aircraft market, establishing a lead in this emerging market.

Two work packages are detailed within the joint technical proposal:

Work Package 5 – VHBR – Middle of Market Technology

Throughout the course of the programme, work package 5 will demonstrate a range of underlying technologies necessary for very high bypass ratio (VHBR) engines in all markets, although focusing on Middle of Market short range aircraft. A series of design studies and rig tests will deliver TRL4-5 for each technology by 2018.

Work Package 6 – VHBR – Large Turbofan Demonstrator

Work package 6 targets the extension of Very High Bypass Ratio technologies to large engines for the long range airliner market. Building on the technology validation delivered by WP5, the project will develop these for higher power engines and ultimately demonstrate the technology at full system level in ground and flight test in order to achieve TRL 6 in 2019 in preparation for the next generation of wide body airliners.

The Very High Bypass Ratio engine architecture is a significant evolution from the Trent family of engines, featuring a gearbox architecture in the compression system which presents any structural component in the engine with a novel environment in which to operate. Therefore, key to both work packages and required in order to meet the significant environmental challenges above, is the development of structural technology in the compression system which forms the subject of this call.

In particular, the research, design, validation and fabrication of fully integrated intercase assemblies

(with a novel configuration and interfaces to other components as defined by the Architectural design of the engine) using advanced manufacturing techniques and optimized for weight, cost and compressor efficiency, for VHBR engine ground and flight test.

In addition the Core-Partner(s) will be required to maximize their contribution to the programme by providing compelling proposals for additional technology or manufacturing development in the area of structural systems which will contribute to the improvement (in weight, efficiency, life, noise, environmental impact, cost or lead-time) of future very high bypass ratio gas turbine engines.

Within the Joint Technical Proposal, Work package 5.1 describes the technology development required, and work package 6.1 integrates the structural technology with other key parts of the wider VHBR engine to form a full system demonstrator.

2. Scope of work

Overall Scope and Responsibilities

The scope of this work package includes; research into and conceptual design / down-selection/ detailed design of an Intermediate compressor case for a VHBR gas turbine engine of an architecture defined by Rolls-Royce, associated technology/manufacturing demonstration including manufacturing trials, rig testing and modelling, and the manufacture of three sets of hardware that will be used for development testing. Two sets of hardware shall be suitable for ground test. One set of hardware shall be suitable for use on a flying test bed.

The program will be divided into two phases:

Phase 1 will consist of conceptual design and technology development as well as detailed program planning. At the end of Phase 1 (Q1 2016), a joint review shall be held between the Core-Partner(s) and Rolls-Royce to ensure that:-

- The design requirements will be satisfied by the selected concept design(s) and associated manufacturing processes (demonstrated through physical trials and tests conducted by the Core-Partner(s) where appropriate)
- The project plan to produce the required sets of development hardware supports the overall engine programme with acceptable levels of risk
- The notional production schedule developed by the Core-Partner(s) and anticipated learned component cost is competitive to alternative design solutions

Phase 2 of the program has the potential to begin after satisfactory completion of Phase 1. Phase 2 of the program consists of detailed design, modelling and/or rig testing (as appropriate), tooling procurement and development hardware fabrication, culminating in execution of ground and flight test of the manufactured components in 2018 and 2019 respectively.

SABRe (Supplier Management System Requirements) is the supplier-facing element of the Rolls-Royce Management System and is applicable to all suppliers or partners who supply product related to Rolls-Royce contracts / purchase orders. The purpose of SABRe Supplier Management System Requirements is to formally communicate Rolls-Royce requirements and expectations to the global supply chain and is available to view and download from the Rolls-Royce Global Supplier Portal (GSP) <https://suppliers.rolls-royce.com>. The applicant(s) will ensure that it is compliant with these requirements.

The applicant(s) will comply with specific technical requirements defined in a Component Requirements Document (CRD) which shall be supplied by Rolls-Royce. The CRD will be the subject of updates as the engine requirements mature.

Rolls-Royce will at all times retain design authority for the Engine, but may delegate responsibility for the design of certain components as detailed below.

The Component comprises of the following parts and such other parts as may be required to fulfil the requirements:-

- i. Intermediate compressor case,
- ii. Wire thread inserts and interference fit dowels etc,
- iii. Thin wall inserts,
- iv. Mounting lug bushes (A-frame and thrust link spherical bearings),
- v. Pressure and Temperature sensor sleeves (Intermediate Pressure Compressor exit),
- vi. Air/Oil System Pipework

All of the above are to be supplied fully fitted as part of an integrated intercase assembly.

Particular attention should be given to the 6 areas described in Figure 1. (The general arrangement provided is for illustration purposes only and are not representative of the VHBR engine architecture).

As part of the work package to design, manufacture and provide the intercase the applicant(s) will be responsible for the aerodynamic design of the gas path from the Intermediate Pressure compressor (IPC) last stage rotor exit to the High Pressure Compressor first stage inlet. Rolls-Royce will define the interface location and flow/functional requirements at inlet and exit to this domain. Targets will be set for the aerodynamic loss within the duct based on current state of the art designs.

In achieving the design requirements it is expected that the applicant(s) will carry out early optimisation studies in conjunction with RR to meet the other cost/weight/stiffness requirements for the Intercase. The applicant(s) will be expected to demonstrate the final design through low speed testing and high fidelity CFD.

Advanced manufacturing techniques and surface finishing technology to minimise aerodynamic loss are to be considered, with a target of achieving 0.8 micron ra surface finish on all the gas path wetted areas. If necessary, manufacturing trials and prototype test pieces should be provided to demonstrate this rather than the full demonstration hardware.

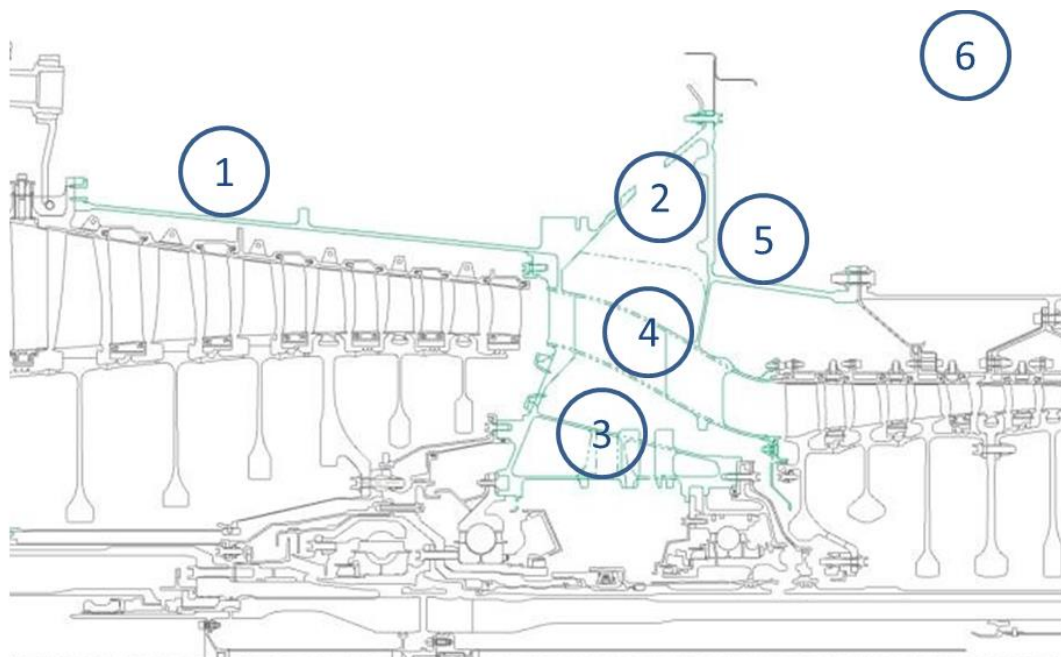


Image: Private – Rolls-Royce Data ©2014 Rolls-Royce plc

1. Optimised stiffness to maintain tip clearances and minimize weight
2. Optimised flanges for reduced weight
3. Optimised structural support – combination of materials to support loads while delivering light weight structure
4. Optimised flow path/aerofoil definition for efficiency (applicant(s) will be responsible for the aerodynamic design of the gas path in the ICC) and optimized surface finish (target 0.8 micron or better)
5. Mount capability
6. Use of additive layer manufacture, composites, various materials where applicable, minimize hard tooling.

Figure 1. VHBR Structural Technology – Integrated Intercase Assembly.

Design Activity Responsibility:

The applicant(s) will conduct design activities for Rolls-Royce using its own design rules and standards.

The applicant(s) shall be responsible for ensuring:

- The design activities in respect of the Components contained in the CRD
- The completion of those items identified as being the applicant's design deliverables

The applicant(s) will produce, and check the final Design Solution, and manufacturing acceptance specifications in a format that will integrate with Rolls-Royce's PLM system. The applicant(s) will provide model updates at regular intervals to RR for the purposes of maintaining the product structure. In relation to the Components, Rolls-Royce reserves the right to review and refuse such Design Solutions and manufacturing acceptance specifications. Rolls-Royce shall not unreasonably withhold approval of such Design Solutions and manufacturing acceptance specifications, and will provide the applicant(s) with detailed rationale of any such refusals. Any approval by Rolls-Royce does not relieve the applicant(s) of any liability in terms of design integrity.

At the Effective Date the required format is Siemens NX and the solid model and Component drawings should be a Siemens NX file supported by a data transfer sheet in line with Joint Engineering Standards and bulletins defined by Rolls-Royce.

Design data (including design schemes, solutions, technical reports and supporting evidence) should be supplied in the appropriate MS office format in a secure location. Where this is not possible, data should be supplied in a format readable by Adobe Acrobat V7. Rolls-Royce will populate its PLM system with this shared data.

The applicant(s) will work to their own internal DFMEA (Design Failure Modes and Effects Analysis) process which shall be accepted by Rolls-Royce.

The applicant(s) will be responsible for achieving TR (technical review) gate approvals in accordance with a process defined by Rolls-Royce.

For the designed components, the applicant(s) will achieve the following technical approvals in accordance with a process ("Design Definition Issue Statement") defined by Rolls-Royce:

- Compressor aero
- WEM
- Air Systems
- Oil Systems
- Module and Engine assembly
- Stress
- Vibration
- Others as required

Technical Report Approval

The applicant(s) must jointly approve all of their own produced technical reports along with Rolls-Royce for reports associated with the Components.

All reports associated with design definitions and analysis will be produced on the applicant's internal proforma.

Supply Responsibility

The applicant(s) is (are) responsible for:

- The supply of the Components
- The sourcing and procurement of material for the Components, including receipt inspection in accordance with the applicant's Quality Management system.
- The manufacture and procurement of the Components.
- The assembly of all parts and sub-assemblies of the Component into the finished Component.
- The provision (whether procurement or manufacture) of tooling required for the manufacturing of the Components. The applicant(s) shall be responsible for all associated manufacturing tooling,

and verification of such tooling, used to manufacture the Component, assemble the Component, transportation equipment.

Interfaces:

All engine interfaces (both physical and functional) shall be identified, owned, and managed by the applicant(s) to a common standard defined by Rolls-Royce. Interfaces shall define physical dimensions and tolerances, materials, temperatures, pressures, thermo/mechanical effects and fluids (air/oil/fuel) at the interfaces.

Configuration Change Management

Details of the mandatory information and templates to be supplied in support of change requests are defined in SABRe. Any changes to the design standard of the components will also be through the Rolls-Royce SRM/PCB process as outlined in SABRe. Rolls-Royce will retain responsibility for the approval and introduction of changes to the technical standard.

The applicant(s) will provide in a timely manner and, if required, present information pertinent to change requests to allow Rolls-Royce's PCB process to be conducted satisfactorily. Similarly Rolls-Royce will provide, in a timely manner, Information pertinent to change requests to the applicant(s) to allow the applicant's change control board process to be conducted accordingly.

Changes to the Component requested by Rolls-Royce or the applicant(s) shall not be unreasonably delayed or denied.

The applicant(s) will be responsible for providing evidence and Information to support the consideration of any applicant(s) proposed changes through the process, including any implications on tooling. The applicant(s) will be required to present proposed design changes at Rolls-Royce's design review meetings.

The part number configuration of the Components will be defined, with the remainder of the Engine, in Rolls-Royce's configuration management systems. This shall be the executive source of this Information.

The applicant(s) will be expected to support Rolls-Royce's requirements in terms of ensuring the Rolls-Royce's PDM system is populated with Component data to allow demonstrator Engine delivery.

Manufacturing Capability Readiness

Technology development shall be considered for integration into the package where applicable. This should include (but not be limited to) additive layer manufacture, composites, welded fabrications, use of castings, use of a variety of materials to maximize performance, minimize weight, minimize cost, and optimize aero definition.

Focus to rapid manufacturing methods should be employed as necessary to help meet delivery and should be weighed against other requirements. As such hard tooling and fixturing should be minimized as necessary to support lower cost and quicker delivery of hardware.

Any alternative or additional manufacturing technologies may be proposed by the Core-Partner(s) for inclusion where it can be demonstrated that the technology has the potential to yield a benefit to one or more product attribute.

Manufacturing Engineering Resource

Manufacturing engineering will be the responsibility of the applicant(s) with support from Rolls-Royce as defined by the scope of the authority granted to the applicant(s).

Assembly and Instrumentation Responsibility

The applicant(s) is (are) responsible for the assembly of all components which comprise the ICC assembly.

The applicant(s) will include instrumentation and associated hardware in the ICC.

Any lead-outs or instrumentation requirements shall be defined in accordance with Rolls-Royce's "Protocol for Experiment and Instrumentation Definition between Rolls-Royce, Component Suppliers and Customers",

Rolls-Royce will support the applicant(s) in due time with the necessary information required to define instrumentation provisions.

Quality Management System Requirements

As this is a demonstrator engine application no FAIR (First Article Inspection Report) is required and sensitive part classification and controls are not required.

The design, manufacturing and assembly will be carried out in compliance with the applicant(s) Quality management system.

Hardware produced for verification purposes (either on-ground or in-flight testing) shall be suitable and appropriately qualified for that purpose.

All evidence and paperwork associated with flight clearance will be provided by the applicant(s).

Engineering

- RR review and approval of the applicant's design work and manufacturing to be handled in the design reviews only. The applicant(s) will handle all approvals of manufacturing processes.

- The final defining documents for the component will be controlled in RR PLM system. Formal change control will be managed in the applicant's system until the final definition is available. Preliminary drawings and models will be controlled in the applicant's system with copies available to RR upon request.

Manufacturing

Manufacturing of hardware will be in compliance with the applicant's system for manufacturing of early development hardware. This system is designed to provide sufficient records to provide knowledge on how the parts were produced (*as opposed to qualifying a manufacturing process up front*) as outlined below:

- No FAIR, limited verification of design characteristics, limited special process approvals, use of non-approved suppliers.

The applicant(s) will supply each Component with a "Certificate of Conformity" document and ship the parts in compliance with SABRe requirement. The document will confirm the features of the individual manufactured Component relative to the agreed design.

Work Breakdown Structure

The applicant(s) will operate as an integral IPT within Rolls-Royce's work breakdown structure for the Components and services set out in this Statement of Work and consequently will have a nominated Integrated Programme Team Leader (IPTL) and be assigned with clear deliverables and requirements.

Communication

Formal communication on technical and engineering issues will be via the ECM system between Rolls-Royce and the applicant(s). The ECM system must be used to formally record the exchange of design or interface data and where it is considered that the transfer of Information needs to be formally recorded. ECM's are not contractual documents. The ECM template will be provided.

The applicant(s) is (are) fully responsible for the generation and maintenance of integrated design and make plans for the manufacturing of the Components, including instrumentation provision. The applicant(s) will be required to operate concurrent engineering processes. The applicant(s) will provide Rolls-Royce with regular visibility of these plans.

Data will be transferred via secured means, such as the web-based software Exostar.

Meeting Structures

The applicant(s) must attend weekly formally minuted IPT meetings with the IPTL to monitor design and manufacturing plans and resolve issues.

The applicant(s) will present technical and programme status at quarterly Supplier Engagement Level 2/3 meetings.

The applicant(s) shall support Technical Review Meetings according to RR / Applicant agreed plan.

Risk Management

Using criteria to be defined by Rolls-Royce, The applicant(s) shall undertake risk assessment and mitigation in accordance with the applicant's Quality Management System.

All risk assessment meetings shall be conducted using the applicant's process and formally minuted and reported to Rolls-Royce, and all mitigation actions promptly tracked to closure.

The applicant(s) shall support Rolls-Royce's technical reviews for the ICC fabricated solution as defined by the Rolls-Royce's Product Introduction Process and shall undertake such work as necessary to ensure that Component design successfully achieves the intended outcomes of these reviews according to the work split principles specified. In keeping with these principles, RR will lead the technical presentation of the base design elements and the applicant(s) shall lead the fabrication and detail elements.

Personnel

The applicant(s) will nominate a Technology Development Plan Owner to be responsible overall for Component development and a programme manager to be responsible for managing the overall Component package.

The primary Rolls-Royce contact for the Applicant in regard to the Clean Sky 2 programme is the IPTL, who in turn reports to the Chief of Sub-System.

Rolls-Royce shall require CVs, or an equivalent summary of relevant experience, for the applicant's personnel in key positions to ensure that they have sufficient experience to undertake the role. For the purposes of this Core-Partner(s) topic description, key positions are deemed to be management and specialist roles.

The applicant(s) will support regular meetings at Rolls-Royce Derby facilities on a bi-monthly basis. The applicant(s) will also host Rolls-Royce personnel at meetings at the applicant's facilities.

3. Special skills, capabilities

Over and above the ability to deliver against each of the requirements described in section 2.1 and 2.2, the applicant(s) shall have:-

- A proven track record of delivering reliability sensitive components to Aerospace gas turbine engines (preferably to Rolls-Royce large civil engines)
- Significant experience within the Aerospace sector to deliver complex fabricated structures.
- Experience in managing complex interfaces in gas turbine engines
- Proven track record of delivering hardware to, and supporting testing of, previous engine development programmes.
- Proven track record of component or subsystem verification
- Access to an established and competitive supply chain and the internal capacity to deliver in the timescales required
- Experience with clearance of hardware suitable for flight test
- Previous experience of low loss inter-duct design and validated 3D aerodynamic design capability
- Previous experience in conducting duct testing including integration with upstream and downstream turbomachinery. This may be achieved through links to established academic institutes with demonstrated experience in this area
- Experience operating within European funding programmes, and with a track record of execute and manage CfPs.
- Experienced and professional Programme and Risk Managers.
- Demonstrated service experience of relevant products in order to optimise and deliver the best possible and robust product in terms of technical accounts, life capability and maintenance.

4. Major deliverables and schedule (estimate)

<i>Deliverables</i>			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
2.1	Intercase Concept and Technology Review	M	Q3 2015
2.2	Programme schedule to deliver 3 Intercase units – End of Phase 1, Decision point for Phase 2	M	Q1 2016
2.3	Intercase Technical Review -PL (program launch)	M	Q2 2016
2.4	Intercase Technical Review -CR (concept review)	M	Q3 2016
2.5	Intercase Technical Review - PDR (prelim design review)	M	Q4 2016
2.6	Intercase Technical Review - CDR (critical design review)	M	Q1 2017
2.7	Intercase 1 st Ground Test Hardware	D	Q1 2018
2.8	Intercase 2 nd Ground Test Hardware	D	Q1 2018
2.9	Intercase Flying Test Bed Hardware	D	Q1 2019
2.10	Intercase (Aero) Preliminary aero design	D	Q2 2015
2.11	Intercase (Aero) Low speed test results	D	Q3 2015
2.12	Intercase (Aero) CFD validation (state of the art test case, low speed test data)	D	Q1 2016

M – Milestone

D - Deliverable

VIII. More advanced and efficient small turbine engines for SAT market

Programme Area [SPD]	SAT		
Capability and Technology Domain	Small Turbine Engines	Work Packages	Eng ITD WP7
Indicative Topic Funding Value	10 M€		
Leading Company	Piaggio		
Duration	70 Months	Start Date	April 2015
Date of Issue		Call Wave	1

Topic Number	Title		
JTI-CS2-2014-CPW01-ENG-04-01	More advanced and efficient small turbine engines for SAT market	Duration	70 Months
		Start Date	April 2015

Short description

This Strategic Topic is related to the ITD Engines (WPE.1 Reliable and more efficient operation of small turbine engines) established for the SAT transversal activities in the Chapter 12 “Small Aircraft Transport (SAT)”, namely in 12.4.2 ITD Engines of the JTP and it is aimed at giving to the potential Core-Partner(s) the overall responsibility of the technology development and validation for next generation durable and efficient small turboprop engines for the business and general aviation markets (such as reference 19 seat aircraft). The call includes ground demonstration of these technologies utilizing a strategy to minimize program costs not specifically associated with the technology improvements.

The design, development and ground demonstration of the innovative small turboprop propulsive system shall be rooted in an existing certified engine with high number of flight hours recorded. This baseline engine will set topic references for technology improvements and for results tracking and measurement.

The technology development efforts will be focused on those areas that have a clear market application in the small turboprop segment, supporting the process of industrial revitalization in the European small turboprop engine sector, resulting in secured orders on new applications and exports outside of EU.

1. Background

As it is envisaged in the Flight Path 2050 and the new SRIA, the challenge of achieving door-to-door trip time within 4 hours in Europe is a goal for the future environmentally friendly multimodal transport system. This creates an opportunity for new innovative air services in an intermodal transport environment; as a consequence, a variety of transport services tailored to individual needs should be developed.

Today, interregional travel on low density traffic connections is mainly carried out by automotive vehicles. Due to the anticipated saturation of road traffic and longer transport distances in the extended European Union, the increasing demand for individual transport cannot be satisfied by road traffic alone. Consequently, a proper balance of individual transport by road, rail and air should be found.

A significant potential growth for the Small Aircraft Transport (Low Capacity Air Transportation) market is expected, arising from highly efficient, highly reliable aircraft which will provide Origin-Destination scheduled and on-demand transport with travel speeds that are four times faster than road traffic speeds and approximately twice as fast as using scheduled air transport between major airport hubs. In this view, one of the key technologies to allow this transport system is to enhance and integrate low cost, high efficient engine technologies to allow operation of the proposed small aircraft transport configuration.

The gas turbine technology has established the dominance in the aircraft propulsion application due to high power to weight ratio and reliability, but its relatively high cost becomes very relevant when the power level decreases for the small aircraft application (< 1000kW). Advanced technology in gas turbines of the recent years has concentrated on large engines with a big impact on improving aviation transport efficiency and greening but only a little effort has been made on small gas turbines. The small gas turbine engine is distinguished from large power engine not so much in terms of overall requirements (reliability, relative lower specific fuel consumption etc.), but rather in the severity of problems associated to achieve these requirements in small dimensions of various engine components and at a cost that will be economically successful in this market. As a result, technology development in this context requires design and manufacturing process innovation focused on increasing efficiency in this product size and at the required market costs.

The European Small aircraft industry has a market position on the global general aviation and utility aircraft market, both pistons and turboprops (excluding business jets and new category of Light Sport Aircraft), of around 33% in value (total market 2002-2011 around \$20Bn) thanks to the technical excellence resulting from past private investments covering all the segments like single/twin engines pistons and turboprops.

The North America and Europe regions have represented the two primary markets for this aircraft category, and have undergone a period of slow growth due to the global financial crisis and recession. Demand from other areas of the globe with higher economic growth, including emerging economies such as China, India, and Brazil, will grow in the next decades to complement orders from customers in North America and Europe. However, the cost of purchasing, maintaining and operating a small aircraft is a serious obstacle to higher growth in this market aviation sector.

Although the general aviation/utility market is expected to remain vibrant throughout the next decade period, the development of a larger use of this category of aircraft in the passenger transport services is strongly related to breakthrough technologies in both power plant and airframe that dramatically reduces the impact on cost.

2. Scope of work

The Topic will address technical challenges to deliver next generation turboprop engines and propeller for up to 19 seats aircraft, proposing step-changes from current state of the art and will deliver important improvements in engine technology, contributing to ACARE SRA goals achievements.

The improvement of fuel efficiency, the extension of service life between overhauls and the reduction of noise footprint will be the main drivers for the technology maturation plan and engine demonstration strategy. Specific attention is paid to technologies able to increase the competitiveness of the European industry in the small turboprop gas turbine engine sector, so far dominated by non-European companies.

This project will specifically deliver technologies sustaining the following high level objectives:

- Up to 15% of fuel efficiency improvement vs 2014 reference engine
- Up to 10% of reduction of total operating costs vs 2014 reference engine
- Contribute to noise reduction including propeller of 10 db
- Maintain and strengthen European competitiveness in Small Air Transport turboprop engines market

The Horizon2020 challenges shall be addressed by taking the following actions:

➔ **toward “Creating resource efficient transport that respects the environment”**

- Sub-system technology development delivering individual improvements in component efficiencies and contributing to the overall system enhancement for fuel efficiency improvement and noise reduction;
- TRL incremental progression through design studies and rig tests to explore the technologies under development and their interactions up to TRL 6;
- Setting a first step towards the goals for 2035 on the way to Flightpath2050, with TRL4-5 advanced technology stream for SAT propulsion system long term innovation.

➔ **toward “Building industrial leadership in Europe”**

- Maintain and strengthen European competitiveness in Small Air Transport turboprop engines market by means of engine major evolutions; developing design and manufacturing technologies with application in both spiral development programs as well as new engine architectures.
- Organisation of an integrated collaborative European partnership for SAT turboprops with the participation of key specialist companies and research institutes.

The topic plan will be focused on design, development and ground testing of a new turboprop demonstrator reaching TRL6 to validate key technologies to reduce fuel consumption and noise emission.

The topic shall be mainly focused on High Pressure Turbine and Power Turbine efficiency improvement, combustor cooling optimisation and low noise propulsion system (reduction gearbox and low noise propellers with integrated control system). In addition, specific attention will be dedicated to develop technologies able to reduce total operating costs through the effective use of additive technology manufacturing methods for SAT market, low cost precision casting, and efficient production technologies for critical engine parts, surface and heat treatment processes.

In the following the subjects in which the Core-Partner(s) will perform its activities are listed:

a. Engine Integration & Coordination

The Core-Partner(s), in cooperation with Small Aircraft integrators, is expected to identify the engine baseline, to set technology roadmaps to achieve the Topic High Level objectives providing consistent assessment of the technical results and environmental benefits that the Topic brings.

The Core-Partner(s) and Small Aircraft integrators will also define metrics and will assess the technology maturation against main targets during the activity development.

Concerning the demonstration strategy, the Core-Partner(s) is (are) expected to provide evidence on the availability and background of experimental facilities and testing engineering capability.

The Partner shall work to an agreed time schedule and work package description and will be managed with a phase & gate approach. The Partner shall be responsible for design, manufacturing, assembly for testing and overall demonstration towards Topic objectives. Periodic progress reports shall be provided by the partner, referring to all agreed work packages, technical achievements, time schedules, potential risks and proposals for risk mitigation.

b. Gas Generator

The Core-Partner(s) is (are) expected to develop and validate advanced Gas Generator technologies aiming at increasing engine thermal efficiency and delivering low weight solutions contributing to the fuel efficiency improvement target.

The introduction of advanced materials and alloys for reliable and durable components enabling high temperatures conditions along with the optimization of secondary air system for high efficient cooling and bleeding solutions shall be considered as holistic approach for advanced gas generator development.

Benefits derived from the introduction of these new technologies are expected to be demonstrated at sub-system level and ground engine demonstration for performance and operability evaluation.

The partner shall be responsible for gas generator design, manufacturing, assembly for testing and technology demonstration against topic objectives.

c. Power Turbine & Exhaust

The Core-Partner(s) is (are) expected to develop and validate technologies for ultra-high efficient power turbine and exhaust system contributing to the overall fuel efficiency improvement.

Advanced aerodynamics features for efficient flow path and airfoil concepts along with optimized solutions for clearance control and secondary losses reduction are expected to be validated.

Specific attention is expected to be given to robust and optimized light weight design and materials solutions. The noise footprint of the power turbine shall be also taken into account contributing to the overall power plant emissions improvements.

The Core-Partner(s) shall be responsible for power turbine design, manufacturing, assembly for testing and technology demonstration against topic objectives.

d. Reduction Gearbox and Low Noise Propeller

The Core-Partner(s) is (are) expected to develop low noise propulsive system, including reduction gearbox & integrated control system for optimal propeller speed and low noise propeller design technologies.

In addition, the Core-Partner(s) is (are) expected to evaluate optimal trade-offs of the whole system in order to maximise propulsive efficiency as well as reduce noise emission and weight.

Affordable manufacturing technologies for key components (gears, bearings) are expected to be developed and validated to reduce acquisition costs as well as reliable and durable design solutions aiming at extending maintenance intervals and reducing operational costs.

Particular attention will be paid to the validation strategy supporting TRL maturation, up to engine validation reaching TRL5-6.

Preliminary studies for advanced configuration (beyond 2030 EIS) are also expected with clear indication of further possible fuel burn improvements.

The Core-Partner(s) shall be responsible for design, manufacturing, assembly for testing and technology demonstration against topic objectives.

e. Engine Demo

The aim is to deliver TRL6 demonstration through appropriate testing delivering engine conditions representative of potential future engine applications.

The Core-Partner(s) is (are) expected to cover the system level integration activities and all build and test activity required delivering the Topic results.

This includes the activities required to support the demonstrator test programme including development of the verification, validation strategies and test schedules; the delivery of the components, module and vehicle build and strip for the engine demonstrator as well as all instrumentation fitting; the management of any required test facility modifications and all tasks associated with build, test and strip activities.

A specific attention will be given to advanced manufacturing technology demonstration for low cost and efficient production. This could include effective use of additive technology

manufacturing methods for SAT market, precision casting, and efficient production technologies for critical engine parts, surface and heat treatment processes.

The partner shall be responsible for engine design, manufacturing, assembly for testing and overall technology demonstration against topic objectives.

f. Beyond-2020 Technologies for small TP

The Core-Partner(s) shall contribute to technology assessment and preliminary development planning of emerging technologies towards the ACARE goals for the period beyond 2020 taking into account high level targets set in Flightpath 2050.

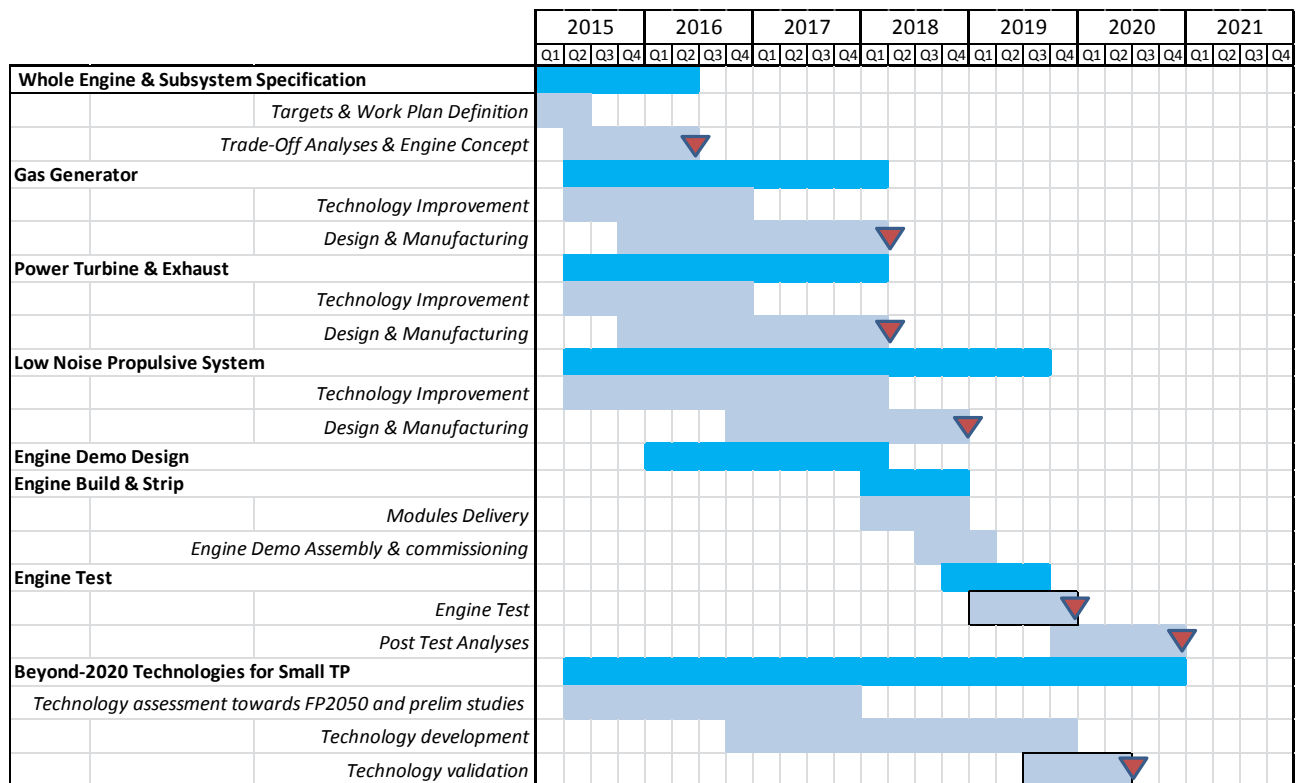
It will be focused on technology assessment, design studies and sub-system validation tests (up to TRL 4-5) for long term SAT powerplant applications (2030).

The Core-Partner(s) is (are) expected to perform an analysis and review of the fuel consumption and NO_x emission technologies which are currently at a low TRL (including hybrid concepts) with the aim to enable develop mature proof of concept demonstrators in the period beyond 2020 and to support a possible Entry into Service [EIS] beyond 2030.

Each subject will contribute to the high level objectives as the following:

	Fuel Efficiency	Noise Reduction	Total Operating Costs	NO _x reduction
High performance Gas Generator	x		x	
Enhanced Power Turbine	x		x	
Reduction Gearbox and Low Noise Propellers	x	x	x	
Beyond-2020 technology preliminary validation	x	x	x	x

A tentative overall schedule for this Topic to be discussed with the applicant(s) is reported in the following picture:



3. Special skills, certification or equipment expected from the Applicant

The Core-Partner(s) is (are) asked to demonstrate proven experience/capabilities in the following subjects:

- Turbine Engines design, manufacturing and certification;
- Test facilities for components, sub-system and whole engine validation;
- Successful application of spiral development process in the field of small turbine engines
- Engine sub-systems design practices for small TP
- Formal technology development process for TRL measurement and tracking
- Product innovation
- Airworthiness knowledge and expertise and a track record of engines successfully developed and in service

4. Major deliverables and schedule

Deliverables			
Ref. No.	Title - Description	Type	Due Date
D1.1	Baseline engine and targets specifications	Report	T0 + 6
D1.2	Trade-off analyses and engine concept	Report	T0 + 12
M2.1	Enhanced Gas Generator preliminary design (PDR)	Milestone	T0 + 20
M2.2	Enhanced Gas Generator critical design (CDR)	Milestone	T0 + 24
D2.1	Enhanced Gas Generator manufacturing for demo	HW	T0 + 42
M3.1	Enhanced PT preliminary design (PDR)	Milestone	T0 + 20
M3.2	Enhanced PT critical design (CDR)	Milestone	T0 + 24
D3.1	Enhanced PT manufacturing for demo	HW	T0 + 42
M4.1	Enhanced RGB & Prop Sys preliminary design (PDR)	Milestone	T0 + 32
D4.1	Enhanced RGB & Prop Sys manufacturing	HW	T0 + 38
D4.2	Enhanced RGB & Prop System validation	Report	T0 + 46
D5.1	Engine test plan	Report	T0 + 36
D5.2	Engine Demo Build & Strip	Report	T0 + 48
M5.1	Engine Test	Milestone	T0 + 58
D5.3	Post Test Analysis	Report	T0 + 63
D6.1	Advanced technologies for next gen small TP development	Report	T0 + 26
D6.2	Advanced technologies validation (mid TRL)	Report	T0 + 42
D6.3	Beyond-2020 technologies final assessment	Report	T0 + 70

5. Definition of terms:

CDR: Critical Design Review

PDR: Preliminary Design Review

PT: Power Turbine

RGB: Reduction Gearbox

TP: Turboprop

TRL: Technology Readiness Level

Clean Sky 2 – Systems ITD

I. Power Electronics and Electrical Drives

Leader and Programme Area [SPD]	SYS		
Work Packages (to which it refers in the JTP)	WP 100.1		
Indicative Topic Funding Value	5 M€		
Leading Company	Dassault / Liebherr / Safran / Thales		
Duration of the action	8 years	Start Date	01/04/2015
Date of Issue	09/07/2014	Call Wave	1

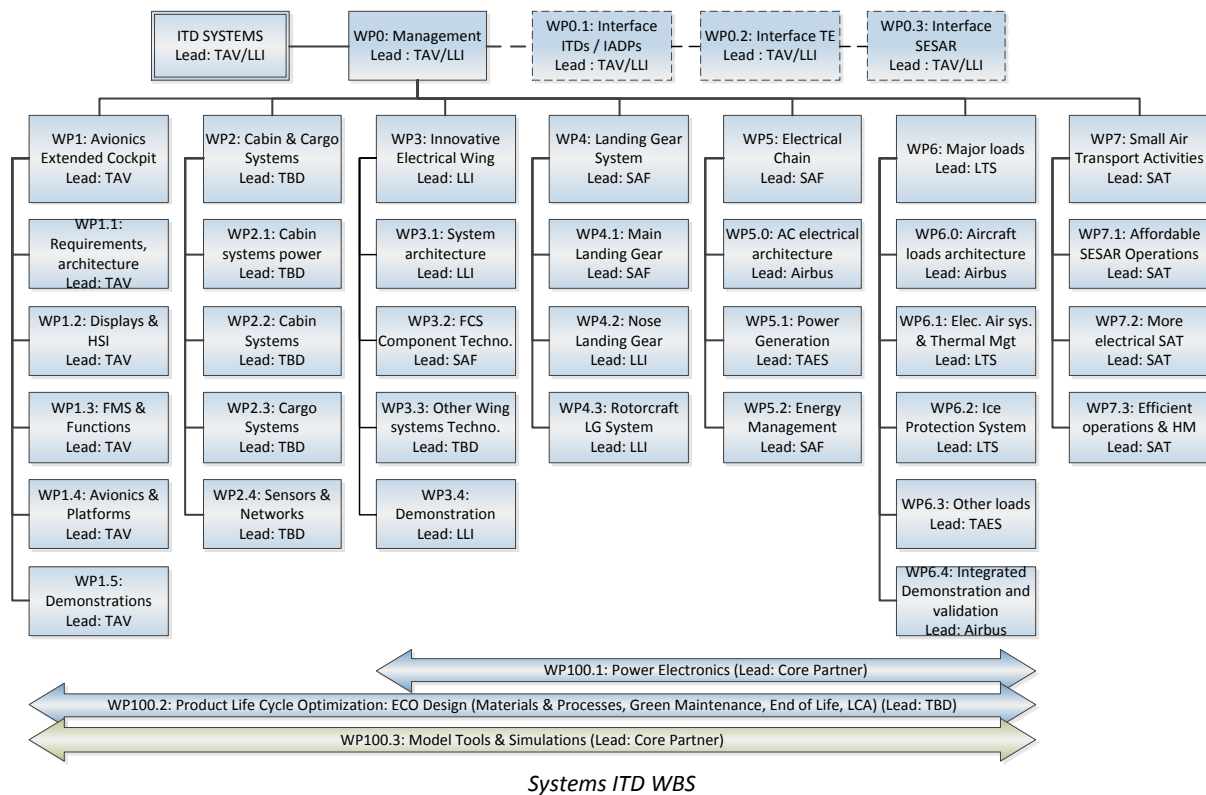
Topic Number	Title		
JTI-CS2-2014-CPW01-SYS-02-01	Power Electronics and Electrical Drives	Duration	8 years
		Start Date	01/04/2015

Short description and terms of reference

1. Background

The ITD Systems is hosting a large amount of demonstrations performed by different equipments manufacturers. The set of demonstrations is covering a very wide panel of use of the power electronics and electrical drives technologies.

Therefore, the ITD Systems Work Breakdown Structure is following a system categories split, organised around six main demonstration sets:

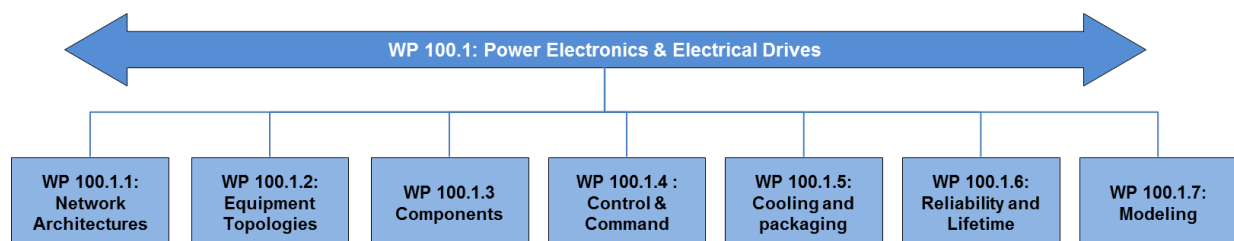


Although these techniques have very different applications, the ITD Systems leaders would like to join efforts on the development of low-TRL technology bricks, which can then be derivated to many different applications onboard the aircraft.

The **Power Electronics and Electrical Drives (PE&ED)** activities are supporting the Leaders demonstrations in fulfilling the High Level Objectives through the following identified benefits:

These technical activities will be hosted in a **transversal work package (WP 100.1)** intended to work on advanced power electronics and electrical drives technologies, as well as on a breaking through embedded systems concept and investigate the reliability and the safety of these technologies and concepts. This WP depicted in green colour, will be strongly linked to the high level work packages 3 to 6 and feed the large scale demonstration with innovative power electronics and electrical drives technology bricks.

This transversal work package will be organized with a matrix approach in order to identify the different skills / expertizes expected for each demonstration foreseen in this Strategic Topic:



Topics for Core-Partners Call 1



WP 100.1 – Power electronics & Electrical Drives - WBS

For each demonstrations, which are detailed hereafter, it is indicated what are the area of expertise which will be used to complete the activity.

The selected Core-Partner(s) expertise will also be implemented at ITD level as a technical advisory agent. The beneficiary should also support the ITD Systems management and the launching of Call for Proposals.

2. Scope of work:

The technical activities are focused on low-TRL technologies design to support the large scale demonstrations with technology bricks to be adapted to each use-case.

These developments will be articulated around seven main streams intended to provide the work packages 3 to 6 with TRL 3 to 4 technologies targetting the inclusion into demonstration, once customised by the leaders.

The following challenges are addressed in the frame of WP 100.1:

- **Network Architectures:** the more electric aircraft will become a reality and a competitive concept for aircrafts' next generations only if the Industry manage to proposed solutions which can be relevant against current hydraulic and pneumatic approaches. Performances, reliability, integration, maintenance, etc. are many aspects to be taken into account in the design phases and will highly influence the high level parameters of the network (architectures, voltage,etc.), as well as the solutions which will be selected for the equipments.
- **Equipment Topologies:** based on the needs identified during the overall electrical architecture and the specifications / performances required, topologies for electrical equipments (power converters, electrical machines, etc.) will be addressed in this WP.
- **Components:** the technology bricks, such as wide gap band components are of utmost importance in order to reach a high "power over weight" ratio compliant with the requirements of the more electric aircraft concept; some other components also have to be studied in order to optimize the various parts of the electric equipments and to comply with their environements. This WP will be dedicated to key enabler technologies for new generation of electrical equipments.
- **Control & Command:** the use of electronics to control the converters and the motors allow to perform complex operations, fine-tune the control of the equipments and enable the integration of new fonctionnalités such as health management. In this work packages, the low power electronics and the software/algorithmes aspects are addressed.
- **Cooling & Packaging:** one of the main challenge in the more electric aircraft is our capability to deal with the thermal management. First step: to reduce as much as possible the losses (thanks to smart topologies, new components and command strategies) which in an electric / electronics systems induced local temperature increase → this first optimisation is addressed thanks to WP 100.1.2, 100.1.3 & 100.1.4. The WP 100.1.5 will address the relevant solutions, from concepts to technologies, in order to manage in the cleverest way the thermal management for the remaining Joule which are still dissipated in the equipments. Activities will focus on solutions minimizing the weight for cooling and packaging.
- **Reliability and Lifetime:** lack of ReTex on how the new technology components age is an

issue to ensure that the introduction of such innovative brick will not induce a failure which did not exist with the previous generation. In order to mitigate such risk, some studies and tests have to be performed on key technologies / equipments to identify and characterized their behaviours during the lifetime. The main objective of this WP would be to perform mechanical, thermo-mecanical or vibration ageing analysis. These tests should allow to create models which can be used for reliability and lifetime prediction.

- **Modeling:** this WP which will be in relation with all the previous one will host the modelling activities dedicated to WP 100.1. The task will deal with individual component modeling as well as more complex models (electrical motor, converters, drivers, network, etc.) and would address both electric and thermal aspects. Ageing analysis tool for both simple components and complex equipments is one of the key output expected.

N.B: WP 100.1.7 (Modeling) will only address “models creation”, it will not cover the creation of tools like specific softwares to run the models, nor development of solver, benchmarking, etc. WP 100.3 “Models, Tools & Simulation” will cover such activities.

Non-exhaustive list of subjects which can be addressed in the different WP (to be refined with the selected applicant(s) wrt there domain of expertise, specific needs arising, etc.):

WP 100.1.1 – Network Architectures:

- Electrical network architectures (e.g. multi sources operating in parallel, secondary power distribution networks, variable voltage, reversible power management, etc.).
- New challenges from HVDC (e.g. partial discharge, standardization, new wiring architecture, etc.).

WP 100.1.2 – Equipments Topologies:

- Power converters topologies, incl. filtering (e.g. multi-level converters, overvoltage protection, current return strategy, etc.).
- Electrical machines topologies (e.g. high reliable or redundant machine architectures, switched reluctance motors, etc.).

WP 100.1.3 – Components:

- Wide Gap Band components
- Components for filters
- Magnetic materials
- Technology bricks for specific environments (high temperature, unpressurized env., mechanical constraints, magnetic constraints using high speed bearings, etc.)
- Sensors
- Wires & connectors in HVDC

WP 100.1.4 – Control & Command:

- Converters switching strategy for loss optimization

- Parallel operations on HVDC network
- Innovative sensorless strategies for electric machines
- Drivers architectures and components

WP 100.1.5 – Cooling & Packaging:

- Air cooling technologies
- Liquid cooling technologies
- PCB cooling technologies
- Packaging optimisation to cope with thermal, mechanical and environmental constraints, incl. innovative assembling technologies, including local heat spreading solutions using liquids, phase change, jets or spray to cool directly the substrate of WBG chips.
- Integrated cooling solutions reducing or eliminating the common mode coupling of fast switching conductors and semiconductors to the converter structure, thereby reducing EMI and eliminating common mode input filters.

WP 100.1.6 – Reliability & Lifetime:

- Wide Gap Band components and actual power components
- New technologies passive components (inductors, capacitors)
- Complex and highly integrated equipments (e.g. electric motors)

WP 100.1.7 – Modeling:

- Modelisation of components, equipments & networks

Liste of activities (demonstrations) which are foreseen to be covered by the Core-Partners in WP 100.1:

Topics for Core-Partners

Call 1



Topics	Link between demonstration Topics and activity streams						
	WP 100.1.1: Network Architectures	WP 100.1.2: Equipment Topologies	WP 100.1.3: Components	WP 100.1.4: Control & Command	WP 100.1.5: Cooling & Packaging	WP 100.1.6: Reliability & Lifetime	WP 100.1.7: Modeling
Mechanical ageing of an high temperature inverter integrated in a electrical motor : Test ,Thermo-mechanical and vibration ageing analysis regarding technologies and assembly solution		X	X			X	X
High temperature motor (300°C) and Power electronic integration (225°C) for a power < 10 kW and 540 Vdc power supply - Solution study - Reliability and lifetime prediction		X	X		X	X	X
High reliability and high availability electrical motor studies for a 540 V PWM power supply with high dv/dt		X	X	X	X	X	X
Predictive reliability models for power components in harsh environmental and high operating constraints			X		X	X	X
Mechanical ageing of a silicon die diode: Thermo-mechanical ageing analysis of a silicon die for harsh environment application			X		X	X	X

Topics for Core-Partners

Call 1



Topics	Link between demonstration Topics and activity streams						
	WP 100.1.1: Network Architectures	WP 100.1.2: Equipment Topologies	WP 100.1.3: Components	WP 100.1.4: Control & Command	WP 100.1.5: Cooling & Packaging	WP 100.1.6: Reliability & Lifetime	WP 100.1.7: Modeling
screwless connection for high current assembling (contact realibility, analyze mechanical constraints)			X		X	X	X
Wide Gap Band components (GaN and SiC) in high operating temperature(Temp>200°C) - Reliability and lifetime prediction - Cooling integration with light packaging and associated simulation models			X		X	X	X
Development of Electrical power train for EMC/Stability and optimisation studies for aircraft applications	X	X	X	X			X
Compact 3-level DC-AC converter power core with integrated advanced power core level cooling solution. External cooling must be air. Validated dynamic thermo-mechanical model of die subjected to self-inflicted thermal flow. Expected reliability & life improvement		X	X	X	X	X	X
Using functional mock-ups built from existing hardware, the Core-Partner(s) shall demonstrate a significant improvement in parallel operation of reversible 270V DC sources over Clean Sky results, when measured according to the same criteria.	X	X	X	X	X	X	X

Topics for Core-Partners

Call 1



Topics	Link between demonstration Topics and activity streams						
	WP 100.1.1: Network Architectures	WP 100.1.2: Equipment Topologies	WP 100.1.3: Components	WP 100.1.4: Control & Command	WP 100.1.5: Cooling & Packaging	WP 100.1.6: Reliability & Lifetime	WP 100.1.7: Modeling
The demonstration may take place on the COPPER Bird(r) electrical test rig in cooperation with leaders and may involve more than 2 sources							
HVDC secondary power distribution network	X	x	X	X			X
High reliability, high speed bearings integrated in the functional mockup of an alternator having a minimum top speed of 30krpm, and the associated reliability study.			X		X	X	X
PCB cooling topic			X		X	X	X
Wide Gap Band components and current power component			X			X	X
Power Core Operation at output (AC) in order to increase power		X	X	X	X		
<i>Optimised EMI filter design based on new magnetic materials and new type of capacitors</i>		X					X
Electrical Drive architecture for actuation systems with centralized power inverters. Core-Partner(s)	X	X	X				X

Topics for Core-Partners

Call 1



Topics	Link between demonstration Topics and activity streams						
	WP 100.1.1: Network Architectures	WP 100.1.2: Equipment Topologies	WP 100.1.3: Components	WP 100.1.4: Control & Command	WP 100.1.5: Cooling & Packaging	WP 100.1.6: Reliability & Lifetime	WP 100.1.7: Modeling
shall compare following architectures: a) Power electronic directly attached at the actuator/motor unit in unpressurized area (e. g. wing) b) Power electronic far away from the actuator/motor unit (5m .. 30m) in pressurized area The investigation shall analyse especially physical effects of long distances between power inverter an motor on inverter electronics, harness and shielding, motor load. Components of the electrical drive system shall be optimized considering safety, electromagnetic compatibility, cost, weight.							

The applicant(s) shall propose a work organisation favoring efficiency, synergies within activity streams and collaboration with leaders.

3. Special skills, capabilities

The selected Core-Partner(s), which can be a single entity or a consortium, should have advanced technological skills and extensive experience in the technologies related to the power electronics and the electrical machine drives, including:

- Electrical power converter topologies and associated modulation/control
- Device packaging techniques for high temperature semiconductors
- Reliability analysis and practical evaluation using suitable non-destructive techniques for power semiconductor modules
- Physics of failure and life time consumption modelling of power semiconductors
- EMC and EMI modelling and practical validation for power conversion systems
- Power semiconductor module design, construction and testing
- Aircraft electrical system power quality and stability modelling and validation
- Filter design, electrical machine design and construction for motor and generator applications
- Embedded control systems including FPGAs and DSPs
- Integrated electrical, mechanical and thermal design and optimisation techniques for power modules and motor drives
- Use and application of emerging WBG semiconductor devices (SiC...) in power converters
- Design of power electronic converters and motor drive systems for aerospace actuation and generation systems
- Thermal modelling, design and testing for power converters and electrical machines
- Sensorless machine control techniques for a wide range of motor types and applications
- Electrical power system simulation and modelling using a range of platforms including SABER, Matlab/Simulink and Modelica

In addition, the understanding of the overall electrical architecture and the next generation networks (such as HVDC 540V and 270V and variable frequency AC systems) are expected in order to match the technology development with the future needs of the aircrafts.

According to the activities foreseen, both academic and industrial skills and capabilities are required, in order to cover the full scope of work starting from trade-off design phase to components / equipments manufacturing (prototypes), testing, evaluation of industrial capabilities in Europe to foster a supply chain for innovative electrical technologies studied in the frame of this WP 100.1.

The selected Core-Partner(s) should have a proven record of bringing the technologies up to at least TRL 4, including the required simulations and physical hardware testing. World leading laboratory based test facilities for power modules, power electronic converters, electrical motor drives and aircraft electrical systems are all required. These facilities must include:

- high power aircraft power supplies [AC and HVDC] as part of a high power, flexible aircraft

Topics for Core-Partners

Call 1



- electrical power system test and validation facility
- environmental chambers for power module temperature, pressure, vibration and humidity cycling
 - 3D X-ray tomography facilities for evaluation of mechanical failure mechanisms in power semiconductor modules
 - 3D laser vibrometry for the validation of thermo-mechanical models at chip scale.
 - electrical machine and power converter construction and extensive high speed motor drive test facilities

Partners or Sub-Contracting can be considered in order to fulfill the test facilities / test means required for this Strategic Topic.

The applicant(s) should have extensive experience of Project Management within large, EU funded aerospace projects with multiple industrial partners and should be able to demonstrate the skills needed to lead this transversal Work Package. Close interfacing with the ITD Coordinator is mandatory but the selected Core-Partner(s) should also steer the work of the partners within the work package.

4. Major deliverables and schedule (estimate)

Deliverables				
Ref. No.	Topics	Title - Description	Type	Due Date
01-01	Mechanical ageing of an high temperature inverter integrated in a electrical motor : Test ,Thermo-mechanical and vibration ageing analysis regarding technologies and assembly solution	Solution Trades of	Report	T0 + 6M
01-02		PDR	Report	T0 + 10M
01-03		CDR	Report	T0 + 16M
01-04		Multi-physic Models	Models	T0 + 16M
01-05		Test Plan	Report	T0 + 16M
01-06		Multi-test Results	Demo	T0 + 28M
01-07		Updated model	Models	T0 + 30M
01-08		Prototype Delivery	Prototype	T0 + 34M
01-09		Final report	Report	T0 + 36M
02-01	High temperature motor (300°C) and Power electronic integration (225°C) for a power < 10 kW and 540 Vdc power supply • Solution study • Reliability and lifetime prediction	Solution Trades of	Report	T0 + 6M
02-02		PDR	Report	T0 + 10M
02-03		CDR	Report	T0 + 16M
02-04		Multi-physic Models	Models	T0 + 16M
02-05		Test Plan	Report	T0 + 16M
02-06		Multi-test Results	Demo	T0 + 28M
02-07		Updated model	Models	T0 + 30M
02-08		Prototype delivery	Prototype	T0 + 34M
02-09		Final report	Report	T0 + 36M
03-01	High reliability and high availability electrical motor studies for a 540 V PWM power supply with high dv/dt	Solution Trades of	Report	T0 + 6M
03-02		PDR	Report	T0 + 10M
03-03		CDR	Report	T0 + 16M
03-04		Multi-physic Models	Models	T0 + 16M
03-05		TEST PLAN	Report	T0 + 16M
03-06		Multi-test Results	Demo	T0 + 28M
03-07		Updated model	Models	T0 + 30M
03-08		PROTOTYPE DELIVERY	Prototype	T0 + 34M
03-09		Final report	Report	T0 + 36M
04-01	Predictive reliability models for power components in harsh environmental and high operating constraints	Solution Trades of	Report	T0 + 10M
04-02		Multi-physic Model	Models	T0 + 12M
04-03		Final report	Report	T0 + 12M

<i>Deliverables</i>				
<i>Ref. No.</i>	<i>Topics</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
05-01	Mechanical ageing of a silicon die diode: Thermo-mechanical ageing analysis of a silicon die for harsh environment application	State of the art of ageing phenomena for die diode	Report	T0 + 6M
05-02		Solution Trades of	Report	T0 + 6M
05-03		Multi-physic Models	Models	T0 + 8M
05-04		TEST PLAN (incl. definition of a constrained profil mission, ageing factors selection, test definition and statistical batch calculation)	Report	T0 + 12M
05-05		Multi-test Results	Demo	T0 + 20M
05-06		Updated model	Models	T0 + 22M
05-07		PROTOTYPE DELIVERY	Prototype	T0 + 22M
05-08		Final report	Report	T0 + 24M
06-01	screwless connection for high current assembling (contact realibility, analyze mechanical constraints)	State of the art and solutions trades of for screwless connection for high current	Report	T0 + 6M
06-02		Low electrical resistance screwless connections design	Models	T0 + 9M
06-03		Multi-physic models	Models	T0 + 12M
06-04		Test plan	Report	T0 + 15M
06-05		Electrical and thermal ageing test of electrical connections	Report	T0 + 21M
06-06		Environmental tests	Report	T0 + 24M
06-07		Updated model	Models	T0 + 27M
06-08		Final report	Report	T0 + 30M
07-01	Wide Gap Band components (GaN and SiC) in high operating temperature(Temp>200°C) - Reliability and lifetime prediction - Cooling integration with light packaging and associated simulation models	Solution Trades of	Report	T0 + 6M
07-02		PDR	Report	T0 + 10M
07-03		CDR	Report	T0 + 16M
07-04		Multi-physic Models	Models	T0 + 16M
07-05		TEST PLAN	Report	T0 + 16M
07-06		Multi-test Results	Demo	T0 + 28M
07-07		Updated model	Models	T0 + 30M
07-08		PROTOTYPE DELIVERY	Prototype	T0 + 34M
07-09		Final report	Report	T0 + 36M
08-01	Development of Electrical	Solution Trades of	Report	T0 + 6M

Topics for Core-Partners Call 1



<i>Deliverables</i>				
<i>Ref. No.</i>	<i>Topics</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
08-02	power train for EMC/Stability and optimisation studies for aircraft applications	PDR	Report	T0 + 10M
08-03		CDR	Report	T0 + 16M
08-04		Multi-physic Models	Models	T0 + 16M
08-05		TEST PLAN	Report	T0 + 16M
08-06		Multi-test Results	Demo	T0 + 28M
08-07		Updated model	Models	T0 + 30M
08-08		PROTOTYPE DELIVERY	Prototype	T0 + 34M
08-09		Final report	Report	T0 + 36M
09-01	Compact 3-level DC-AC converter power core with integrated advanced power core level cooling solution. External cooling must be air. Validated dynamic thermo-mechanical model of die subjected to self-inflicted thermal flow. Expected reliability & life improvement	Solution Trades of	Report	T0+8M
09-02		Test plan	Report	T0+10M
09-03		PDR	Report	T0+12M
09-04		CDR	Report	T0+18M
09-05		Models (behavioural + die physics)	Models	T0+20M
09-06		Functional mockup	Physical model	T0+22M
09-07		Test results	Report	T0 + 24M
09-08		Reliability & life improvement final report	Report	T0 + 25M
10-01	Using functional mock-ups built from existing hardware, the Core-Partner(s) shall demonstrate a significant improvement in parallel operation of reversible 270V DC sources over Clean Sky results, when measured according to the same criteria. The demonstration may take place on the COPPER Bird(r) electrical test rig in cooperation with leaders and may involve more than 2 sources	Solutions Trades of	Report	T0 + 1M
10-02		Engineering Change Memo	Report	T0 + 6M
10-03		CDR	Report	T0 + 7M
10-04		Models (functional)	Report	T0 + 10M
10-05		Acceptance tests	Report	T0 + 12M
10-06		PROTOTYPE DELIVERY	Prototype (x4)	T0 + 12M
10-07		Integration tests report	Report	T0 + 16M

<i>Deliverables</i>				
<i>Ref. No.</i>	<i>Topics</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
11-01	HVDC secondary power distribution network	Simulation Model of a HVDC secondary power distribution network including its components and units (e. g. AC/DC converter, harness, several motor inverter loads (3 kW))	Models	T0 + 6M
11-02		Analysis and simulation investigations for the above mentioned network concerning power buffering and management, network stability, emc compliance	Report	T0 + 9M
11-03		Laboratory test setup of a HVDC secondary power distribution network including its components (integration of given components and units e. g. AC/DC converters, motor inverters)	Report	T0 + 12M
11-04		Extensive test and verification investigations including corresponding reports	Report	T0 + 18M
12-01	High reliability, high speed bearings integrated in the functional mockup of an alternator having a minimum top speed of 30krpm, and the associated reliability study.	Trade studies	Report	T0 + 12M
12-02		PDR	Report	T0 + 13M
12-03		Test plan	Report	T0 + 13M
12-04		Engineering Change Memo	Report	T0 + 15M
12-05		Updated model	Model	T0 + 16M
12-06		Integration & tests	Demo	T0 + 18M
12-07		Final report	Report	T0 + 18M
13-01	PCB cooling topic	State off the art of control PCB cooling and high current PCB cooling	Report	T0 + 6M
13-02		Prototyping	Models	T0 + 14M
13-03		Thermal test and associated reports	Report	T0 + 24M

<i>Deliverables</i>				
<i>Ref. No.</i>	<i>Topics</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
14-01	Wide Gap Band components and current power component	State of the art of ageing phenomena for active and passive power components	Report	T0 + 6M
14-02		Definition of a constrained profil mission wich will be a synthesis of different aircraft missions	Specification	T0 + 12M
14-03		Ageing factors selection, test definition and statistical batch calculation	Report & Modeling	T0 + 24M
14-04		Combined test on chosen components	Mock-up & Report	T0 + 36M
14-05		Associated reliability modes calculations	Models & Reports	T0 + 48M
15-01	Power Core Operation at output (AC) in order to increase power	Definition (identification) of suited power core (e. g. 10 kVA) and analysis of parallel operation of two power cores with regard to parallel operation at the output		T0 + 12M
15-02		Verification with mock-up and identification of penalties (extra components for balancing, additional losses, synchronization effort of PWM and ...)	Mock-up & Report	T0 + 24M
16-01	Optimized EMI filter design based on new magnetic materials and new type of capacitors	Identification of new materials for filter design (magnetic materials, new capacitors)	Report	T0 + 12M
16-02		Generic optimized filter design for inverter output and benchmarking the potential of the new components	Report & Modeling	T0 + 24M
17-01	Electrical Drive architecture for actuation systems with centralized power inverters.	Simulation model of the electrical drive system with it's components	Models	T0 + 6M
17-02		Trade study and comparison of the defined architectures	Report	T0 + 9M

Topics for Core-Partners Call 1



<i>Deliverables</i>				
<i>Ref. No.</i>	<i>Topics</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
17-03		Laboratory demonstrator of an electrical drive system (3kW) including optimized units and components (inverter/filter, harness/shielding, ...)	Demo	T0 + 12M
17-04		Verification of simulation model and optimization of the laboratory demonstrator	Demo & Report	T0 + 18M

Please note that “T0” of each demonstration will be discussed on case by case basis

In addition to these deliverables, linked to the actual demonstrations which are foreseen, a batch of synthesis reports are expected to gather all the experience and observations which will arise from the activities. These synthesis reports will be based on thematic which will be agreed between the Core-Partner(s) and the Leaders. In a first approach, the following reports are foreseen:

T01-01	Electrical Network Architectures for Aircrafts' next generations	Intermediate Report	Report	T0 + 48M
T01-02	Electrical Network Architectures for Aircrafts' next generations	Final Report	Report	T0 + 96M
T02-01	Electrical equipments' topologies for More Electric and More Composite Aircrafts	Intermediate Report	Report	T0 + 48M
T02-02	Electrical equipments' topologies for More Electric and More Composite Aircrafts	Final Report	Report	T0 + 96M
T03-01	Next generation of components for electrical equipments	Intermediate Report	Report	T0 + 48M
T03-02	Next generation of components for electrical equipments	Final Report	Report	T0 + 96M
T04-01	Drivers and Control Command for future applications in aeronautics	Intermediate Report	Report	T0 + 48M
T04-02	Drivers and Control Command for future applications in aeronautics	Final Report	Report	T0 + 96M
T05-01	Global and local thermal management optimisation	Intermediate Report	Report	T0 + 48M
T05-02	Global and local thermal management optimisation	Final Report	Report	T0 + 96M
T06-01	Reliability & ageing of electrical components and equipments	Intermediate Report	Report	T0 + 48M
T06-02	Reliability & ageing of electrical components and equipments	Final Report	Report	T0 + 96M
T07-01	Modeling database	Intermediate delivery	Database of models	T0 + 48M
T07-02	Modeling database	Final delivery	Database of models	T0 + 96M
T08-01	Evaluation of industrial capabilities in Europe for an adequate "electrical components" supply chain for aeronautics applications	Intermediate Report	Report	T0 + 48M

Topics for Core-Partners Call 1



T08-02	Evaluation of industrial capabilities in Europe for an adequate “electrical components” supply chain for aeronautics applications	Final Report	Report	T0 + 96M

II. Model, tools, simulation and integration

Leader and Programme Area [SPD]	SYS		
Work Packages (to which it refers in the JTP)	100.3: Model, tools and simulation		
Indicative Topic Funding Value	5 M€		
Leading Company	Thales, Liebherr, Safran, Dassault, Airbus		
Duration of the action	8 years	Start Date	31/01/2015
Date of Issue	09/07/2014	Call Wave	1

Topic Number	Title		
JTI-CS2-2014-CPW01-SYS-03-01	Model, tools, simulation and integration	Duration	8 years
		Start Date	31/01/2015

Short description and terms of reference

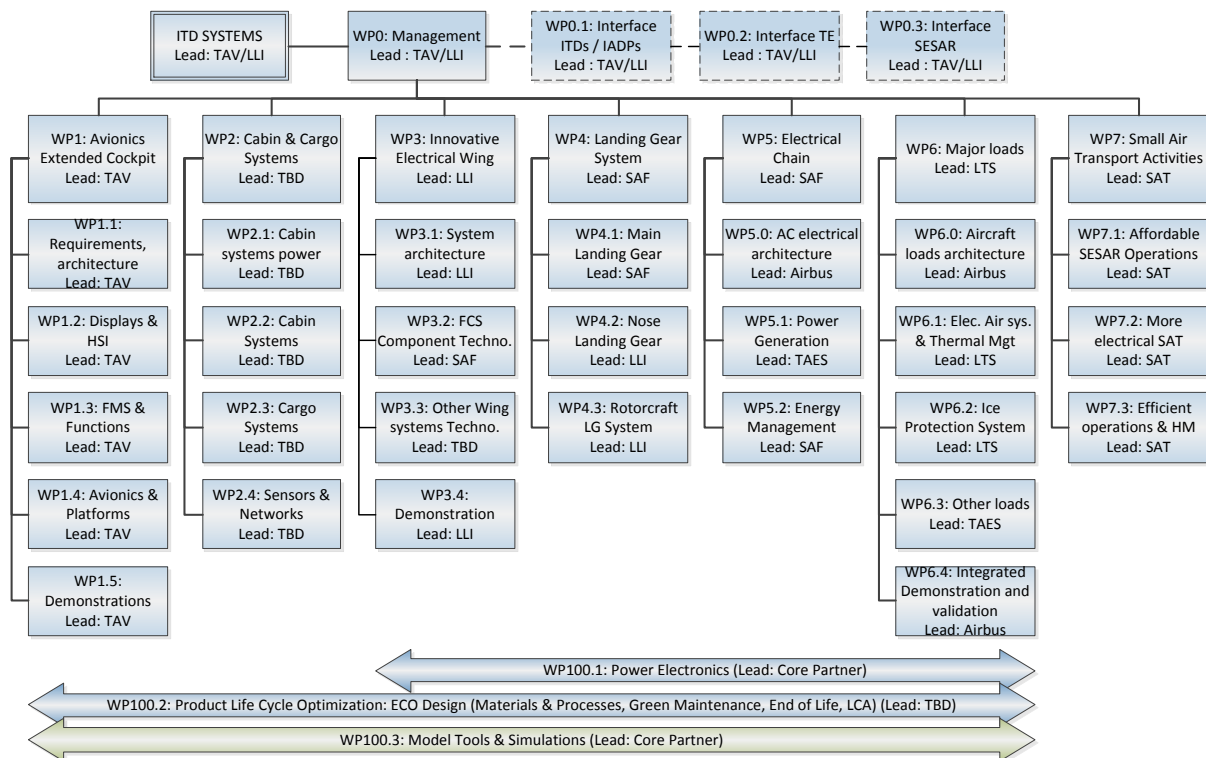
1. Background

The ITD Systems is hosting a large amount of demonstrations performed by different equipment manufacturers and system integrators. The set of demonstrations is covering a very wide panel of technologies and products.

These products are being created separately and feature very different applications of technologies. Despite these considerations, the ITD Systems wishes to centralise as much as possible architecture, simulation modelling and evaluation activities in a transversal activity linked to all the main stream work packages.

These technical activities will be hosted in a transversal work package focusing on different levels of simulation detail, fidelity and accuracy, from the component and integrated systems to the overall aircraft architecture. These activities will enable the ITD systems to work on a common basis for the simulation.

Therefore, the ITD Systems Work Breakdown structure is following a system of categories split and organised around 6 main demonstration sets:



The work package 100.3 will be strongly linked to the high level work packages and support the large scale demonstration with common simulation and modelling methods and tools. Specific work related to an aircraft type will be linked to corresponding work packages, for instance WP 6.4.5 "Integrated demonstration and validation" for large aircraft. Simulations at the correct level of fidelity and accuracy may be used to replace some of the physical tests expected to take place on physical demonstrators.

The scope of the topic will also include some support to the technology bricks integration and customisation for high TRL demonstration.

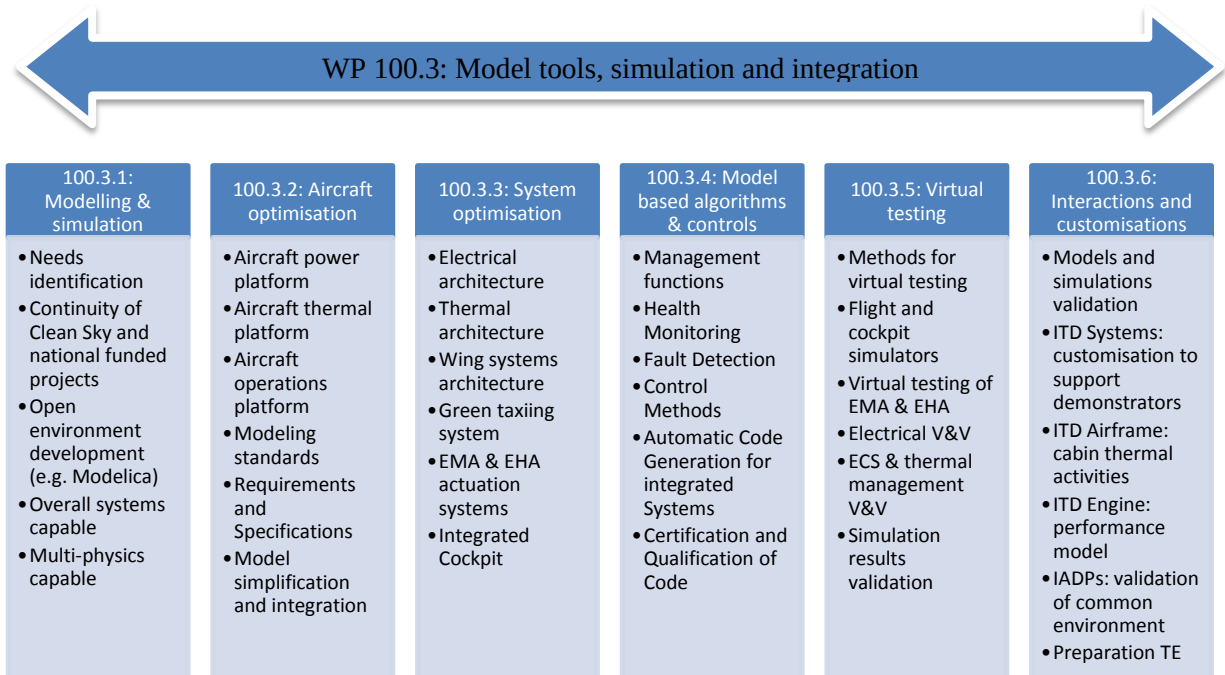
The selected Core-Partner(s) expertise will also be implemented at ITD level as a technical advisory agent. The beneficiary should also support the ITD Systems management and the launching of Call for Proposals.

2. Scope of work:

The technical activities are focused on virtual engineering functions, targeting the support of the demonstrations and bringing a common understanding of the new systems impacts on the aircraft configuration, but also the interactions between systems.

These activities should bring a high level of harmonization to the systems area on modelling and simulation, in order to then integrate the virtual testing capability into the systems developments. In that sense, this transversal activity will have to experience a strong connection to the other ITDs and IADPs inside Clean Sky 2. A link to the advanced demonstrations within the ITD is also foreseen, but the exact level of information transfer will be negotiated with each Demonstrations leader prior to bringing it to life. A yearly review with all involved ITD Systems leaders will be set-up to review work progress & results and state on project continuation or re-orientation.

As a proposed structural integration into the program, the applicant(s) may find hereafter a provisional work breakdown structure:



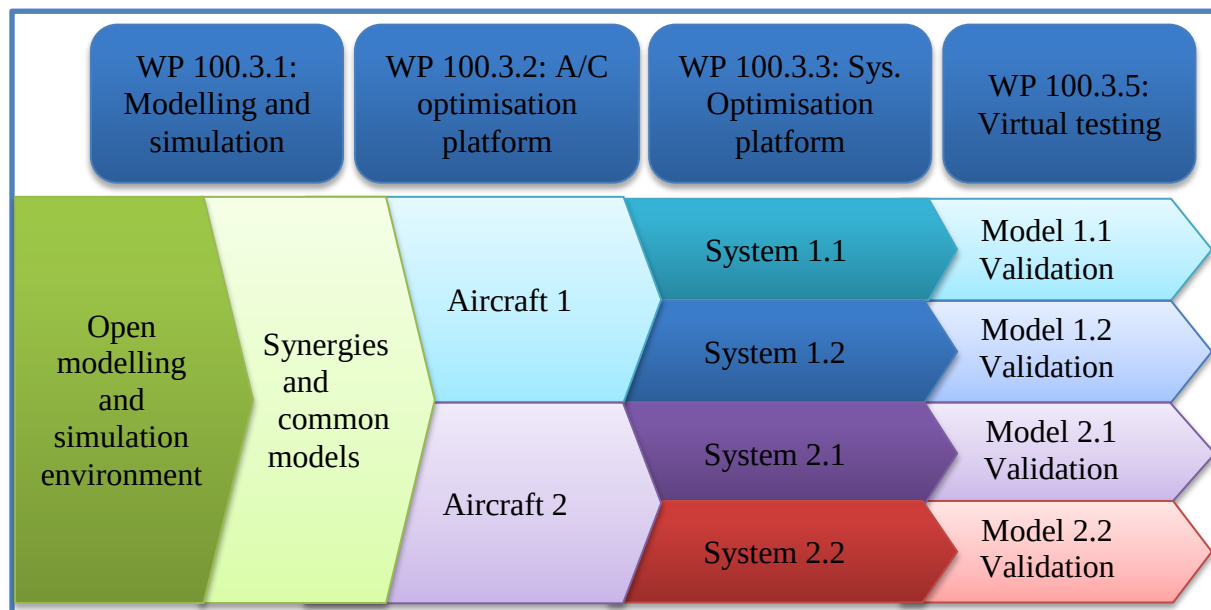
Of course, the topic application might contain enhancements to be considered by the call emitters.

- **Philosophy and Implementation:**

The modelling and simulation activities will be implemented over the whole ITD Systems. Their goal is to create validated tool chains and component libraries built around open standards, which can be replicated throughout the aerospace industry to foster a larger use of models in data exchanges between companies during the development of new aircraft configurations and systems. At all stages of their development, these new tools and libraries will be tested and exercised by the Core-Partner(s) to support various demonstrations during the whole development and validation cycle.

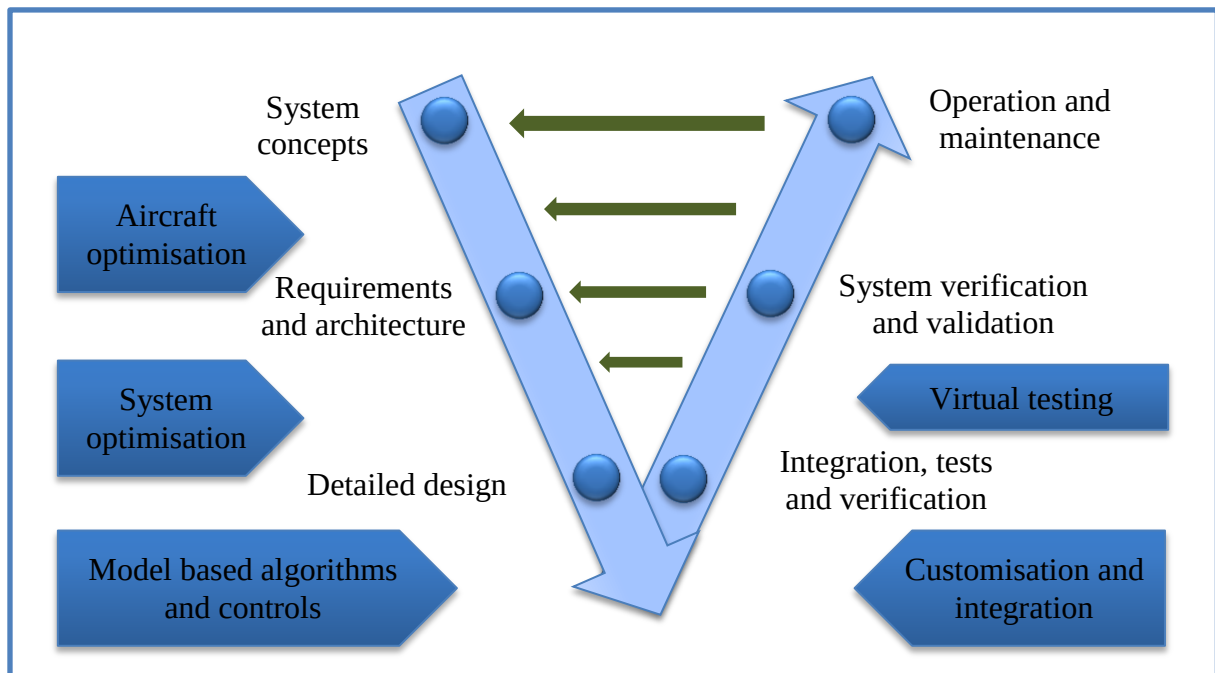
The core modelling environment has to be adapted to different platforms and technological issues with specialised additions and a customisation layer. From these aircraft platforms on, the modelling and simulation capabilities will be customized jointly by the selected Core-Partner(s) and the demonstration responsible companies.

The overall philosophy may be summarized to the following scheme:



The activities will support the whole development and validation process, starting with defining the specifications and requirements, until the verification and validation.

The proposed implementation of the modelling and simulation activities is the following:



The applicant(s) may propose alternative implementation or improvement to be discussed then with the leaders.

- **WP 100.3.1: Modelling and simulation:**

This activity has to deliver the core modelling and simulation environment. The core environment shall provide the following functionality:

- Open modelling environments: as a minimum one modern standardized modelling environment shall be supported, for instance Modelica. Attention will be given to the modelling environments used in other ITDs and IADPs.
- A simulation environment capable of executing models made from sub models created using any of the available modelling environments. The technical solution proposed shall be based on open, non-proprietary and well supported standards. FMI is suggested.
- A model validation functionality facilitating the confrontation of model results with experimental results measured during physical tests. The functionality shall support the complex validation processes required to validate modelling methods and libraries.
- An experimentation facility capable of simulating large models in the context of thousands of product life situations, or scenarios, as a batch on a remote server. Available modelling tools from Clean Sky will be available to the Core-Partner(s) for analysis and possibly adaptation. Direct injection of test results (e.g. as boundary conditions) and live links with parametric tools like CATIA and Matlab would be appreciated.
- A model and data reduction functionality: a general method applicable to model and data set

reduction would be preferred. Combining an experience plan applied to a model in order to generate an intermediate data set, or an experimental data set, with a model parameter identification strategy may give good results. In addition, generic table or polynomial based models should be developed as targets for model and data set reduction operations, and specific functions for further reduction of these models based, for instance on principal component analysis or least error algorithms, would be useful. Automatic calculation of statistic indicators expressing the distance between the original model or data set, and the reduced model seems necessary.

- An analysis function which will inspect the large sets of simulation results produced by experience plans, and will perform a flexible synthesis of results. This function shall be extensible to new kinds of syntheses through an open interface. As a minimum, this function will offer the nonlinear optimization under constraint algorithm, which is needed to optimize at aircraft and subsystem levels.
- A data management function designed to facilitate the storage, organization, and the transfer of models, experiments and results between users of the core modelling and simulation environment.
- An integration function, which as a minimum will be a scripting facility, having the capability to define work processes using all the other functions of the core environment, and extensions. The availability of robust optimization algorithms and user friendly graphical user interfaces in this function would be a plus.

After the achieving of TRL 4, WP 100.3.1 shall also investigate the following topics:

- Collaboration Processes and IP Protection: Based on this core modelling and simulation environment, the Core-Partner(s) will propose, try out and document Processes for Collaboration and IP Protection.

In this activity the Core-Partner(s) shall optimise the way of working together of the different entities in the ITD Systems when related to the modelling and simulation. This is a very important aspect of such a sensitive and collaborative platform.

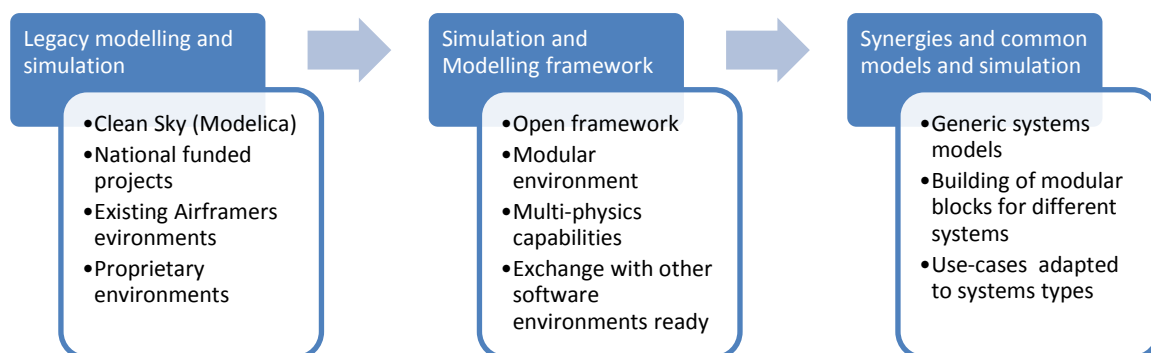
- Modelling Standards: At aircraft level, models and simulation environments should be harmonised and standards defined to enable the different entities to work according to the same standards and as a driver for virtual testing capabilities.
- Requirements & Executable Specifications: The overall aircraft requirements broken down to the systems levels should be collected and available. Also, future aircraft requirements estimations should be extrapolated from the existing requirements database.

The modelling and simulation environment aims to be widely used in the aeronautical sector and should be made accessible to the whole Clean Sky 2 community. Furthermore, it should be compatible with the existing models out of other ITDs or IADPs.

Even if the link is not implemented for all these existing models, the developer documentation of the core environment will describe in detail how other commonly used modelling environments should be connected to the core. As a minimum, interfaces to Modelica, Matlab/Simulink, Excel, FORTRAN and C/C++ shall be investigated.

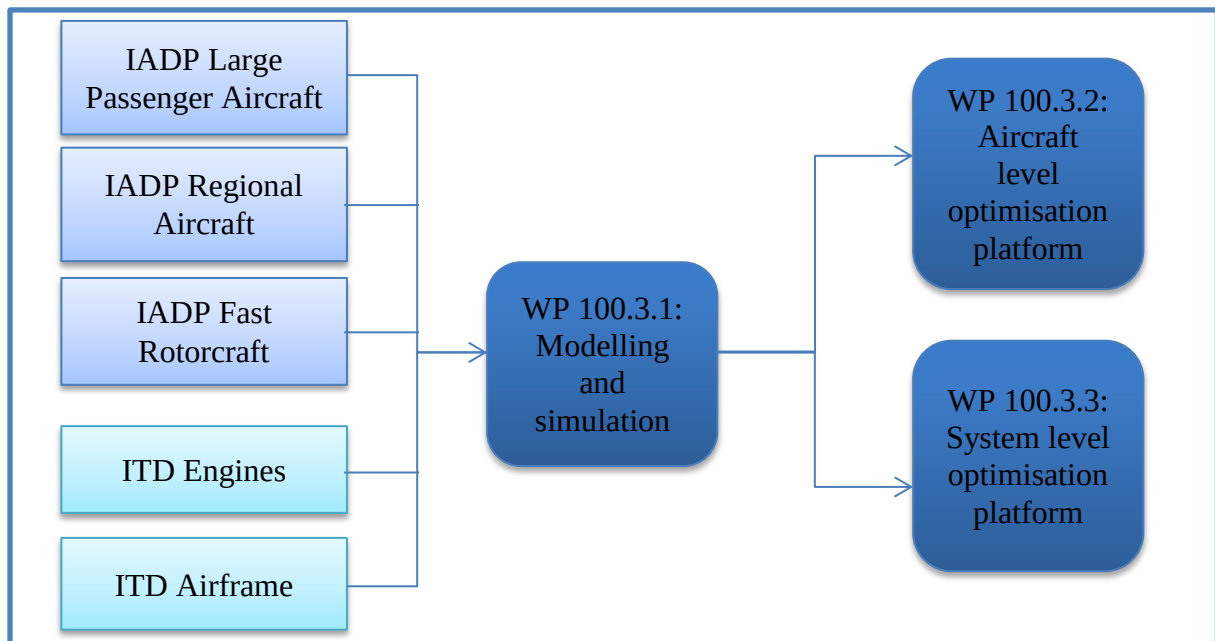
Indeed, the continuity with existing activities has to be ensured, and the openness to other simulation modules has to be maintained. The full environment should be able to behave as such, and to be implemented thanks to company specific tools to gain accuracy and reliability.

In the generic development activities, the Core-Partner(s) shall focus on the design of an open modelling and simulation environment using as few different languages as possible while covering the whole systems' needs. The simulation and modelling core shall be customisable to different flying platforms and then to each independent system demonstrator. Though, the generic environment should identify as much synergies as possible and be provided with common models, before refining in the next work packages.



It would be highly appreciated that the framework will also enable data exchange with the main existing softwares, such as CATIA, Matlab / Simulink, etc.

This framework development activity shall work jointly with other ITDs, IADPs and previous collaborative programs, such as Clean Sky.



- **WP 100.3.2: Aircraft level optimization platforms:**

The impacts of the systems on the overall aircraft behaviour should also be understood, as the ability to evaluate the changes via simulation and modelling would highly improve the development speed of the systems manufacturers.

This activity will deliver to system integrators, a framework for optimization tasks using aircraft-level metrics, like block fuel or NO_x emissions. These metrics are typically the responsibility of integrators, either large systems suppliers or aircraft integrators. There is a strong connection with the TE.

This framework will be based on the core simulation environment to which specific customizations and additional functions will be added by the Core-Partner(s) and interested system integrators.

Concurrent engineering processes are used during the development phase of new aircraft programmes. Usually, in early development phases, the aircraft geometry has a number of open parameters, and a very simplified representation of on-board systems is used. The corresponding activities led by research laboratories and aircraft integrators rely on parametric airframe models, and reduced parameterized aerodynamic performance models. Design degrees of freedom are progressively removed until the shape, mass and balance of the new design is frozen.

While the aerodynamic shape is being finalized, engineers are performing trade studies at systems level. During this phase it is interesting to assess the aircraft level impact of various high level choices regarding on-board systems design. Some choices can have very significant impacts because the capabilities of the aircraft after one or two failures can be very different with different options.

Physical segregation is a safety-minded approach which increases design robustness. It was never perfect and the simple fact of putting two systems in the same airframe creates interactions with

each other. For instance noisy systems can induce a requirement for better soundproofing of the cabin, but this insulation impacts the operation of the temperature control system. Enlarging an electro-hydraulic pump placed in the pressurized area causes higher thermal losses which must be controlled by adequate ventilation or increased cooling power, and so on.

Clean Sky experience with thermal / electrical models shows that it is practical to assemble such models for whole aircraft, or sizeable portions of aircraft. The level of detail and the accuracy must be limited with current computers and simulation tools, but the resulting models are detailed enough to capture subsystem-level details.

In the architecture of all the systems together it must be acknowledged that the redundancy of critical functions is assured sometimes by system-level redundancies (multiple identical subsystems, for instance a double pack ECS architecture), or aircraft level functional redundancies (same function is offered by distinct systems, for instance an ECS operating from engine bleed air, and an open cockpit window both provide ventilation, even though they come from different ATA chapters). The increasingly important requirement of dissimilarity in the subsystems providing the same critical function makes it more likely that subsystems providing a critical function could be sourced from different suppliers. The correct level of detail for an on-board systems model is when all the redundancies are described.

To the extent that they affect block fuel for the reference mission, the accuracy of these models must match the accuracy of cruise specific fuel consumption predictions available to the integrator. Other than that, they must correctly gauge various power flows in relation to each other.

The Core-Partner(s) shall deliver a configuration of the framework in which one of the co-optimised system models represents a parameterized airframe with a reasonably low number of degrees of freedom. The co-optimiser will find optimum values of these degrees of freedom, which could be for instance the wing area or the nominal engine thrust.

Also, this activity shall investigate the possible improvements of the collaborative work between different systems companies, being facilitated by a better understanding of the aircraft operations and common simulation means.

- Aircraft Power Platform:

This new component of the modelling environment offers advanced functions for the design and optimisation of on-board energy management strategies. For architectures suitable for power or energy management, this component will deliver the model of a control component which implements the energy management policies of the demonstrator.

This addition will also give an insight on the effect of energy management policies on the design of the systems and the aircraft, including the possibility to trace flows of energy from source (alternators) to loads, and from storage (fuel tanks) to storage (atmosphere).

Finally this component will include an optimum storage solution picker which will propose the best associations of energy storage technologies to cover a captured power consumption profile. The component libraries will be extended with models of single technology and hybrid, optimised storage

components.

- Aircraft Operations Platform:

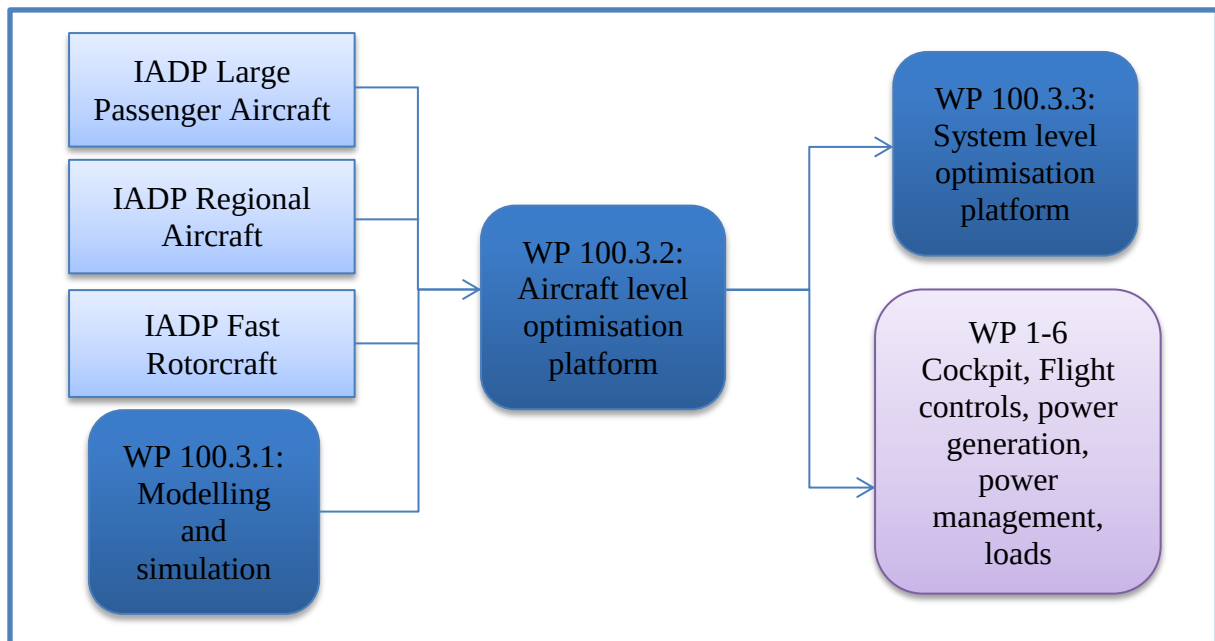
The aircraft operations will also be strongly connected to the systems architecture and definition. In particular, the flight operations and on ground operations have to be better understood and future alternatives have to be traded.

This functionality will be contained in an addition to the core modelling & simulation tool:

- Description of utilization scenarios covering all relevant operations. This part should not only be flexible enough to cover any type of operation, present or future (e.g. green taxi), and any type of aircraft. The focus should be to understand what would be the benefits in changing the operations, but also what is realistic in terms of infrastructure (e.g. hydrogen fuel cell) and legislation.
- Provide environment parameters for any point of the mission, including mission variants with deviations caused by inflight emergencies. These parameters shall include the orientation and intensity of solar radiation, the pressure altitude/flight level, the static temperature, the true airspeed, the wind, air liquid water content and a description of freezing conditions, tarmac/taxiway/runway size, surface nature, contamination and slope, towing/pushback operations, and all the useful derivative parameters like total temperature or Mach number. The environment description must be sufficient to run a simulation of braking with a worst case use of the anti-skid system, or a simulation of flight preparation activities requiring battery power for instance.
- Calculate the aircraft weight and balance including the configuration of jettisonable loads and fuel configuration. For civil airplanes, jettisonable loads include systems and structure parts whose in-flight loss is expected to be demonstrably survivable (e.g. landing gear doors, jettisonable canopies or emergency egress doors or panels, burst tyres, uncontained engine failures...).

In order to perform both functions this model will maintain a tree structure of all non-extremely improbable mission outcomes, based on proposed airplane flight manual procedures and cockpit automation. Ideally, it will offer the possibility to record these scenarios during a piloted (real time) session, or to create them through data entry, or both using rule-based generation.

Additionally it shall have a plug-in interface allowing a connection to detailed models of airport environments (airports with specific performance requirements or departure procedures, specific runways used for certification, flight test locations...)



- **WP 100.3.3: System level optimization platforms:**

As a first understanding and mutualisation, the transversal activity will support the Systems manufacturers with an optimization platform at system level, based on the main strong interactions areas for systems inside the aircraft:

The system-level or systems-level framework configuration shall ensure interoperability with existing Modelica environments and have the necessary interfaces with:

- Models of each engine (they can be dissimilar due to installation differences or different sets of accessories, for instance a Dassault Aviation Falcon central engine vs a lateral engine), including the interfaces necessary to calculate fuel flow and thrust as a function of power setting and power offtakes. Simplified engine models would be used for system-level optimisation since the fuel tank volume is usually already frozen. The more electric aircraft trend blurs the interface between the systems and the engines. It shall be possible to change the perimeter of the engines, for instance to include embedded generation, without breaking the framework.
- A model of relevant parts of the aircraft and its systems which will be used to compute the required level of performance for each function of each subsystem, and the associated side-effects (e.g. thermal losses) which can be the most significant inputs to other systems. This model will include failure propagation from subsystem to subsystem and will be connected to the fault trees (see below) through dedicated failure mode components. The assumptions regarding failure propagation shall be tuneable, but in any case it shall be possible to use the pessimistic assumptions customarily used in safety analyses.

- Analytic, catalogue-based or reduced mass models of subsystems. These will be mechanical models which will provide the correct mass and subsystem centre of gravity position. A mass model takes as input a vector of performance situations taken as constraints (minimum required performance) and outputs sets of design parameters yielding minimum mass. Mass models formulated both as optimization problems and as inverse problems shall be supported.
- Analytic or statistical, environment dependent reliability fault trees for relevant failure modes of each subsystem. These models will be used to check that reliability assumptions which were used to design the architecture remain valid. The functionality shall be configuration to match airworthiness calculation assumption (standard day), or other relevant conditions (dispatch for a given operator).

- Electrical architecture:

The framework will be used to optimize the electrical architecture. The Core-Partner(s) will lend its expertise in aircraft system to help system integrators develop their own models of the rest of the architecture. The Core-Partner(s) shall deliver a generic aircraft model which only has to be associated with an electrical architecture to create a complete model of an aircraft with a level of detail and a level of accuracy suitable for electrical system optimisation.

In addition the Core-Partner(s) shall propose a specific electrical architecture design environment which will provide guidance to the designer for local and global optimisation. The Core-Partner(s) shall also support leaders willing to integrate their own electrical architecture optimized design tools in the framework (for instance the THALES ADVANCE tool).

- Thermal architecture:

The thermal architecture is made of two parts:

- Air and heat circulation in the airframe.
- Systems used to ventilate, oxygenate, pressurize and purify the air injected in various compartments of the airframe.

The AIRFRAME ITD will provide a modelling method and the associated tools required to create a thermal model of the airframe in Modelica. The Core-Partner(s) shall cooperate with the AIRFRAME ITD to extend the modelling method, to add connections with models of the pressurization, temperature and moisture control systems (ECS). Parasitic heat losses are usually major contributors to the heat balance of the fuselage. Thermal models of subsystems and components will be built by the Core-Partner(s) following conventions defined in Clean Sky 2 and available from the AIRFRAME ITD in Clean Sky 2.

The method which currently addresses the prediction of temperature profiles seen by new kinds of electronic components found in the more electric aircraft will be further expanded in Clean Sky 2 to cover crew and passenger comfort and/or physiology (distress).

- Wing architecture:

In the development of the wing of the future, the systems suppliers are investigating different possibilities in the systems environment, but there is also a need of understanding the future kinematics and the impact of these changes on the systems, for instance on the space envelope or on the power distribution.

The Core-Partner(s) shall offer different trade studies on the future wing model and integrate the system architecture resulting of the discussions that will happen with the leaders during the whole program.

The same framework will be used to optimize the architecture of the systems installed in the wing (control surface actuation, fuel storage, engine mounts, landing gear actuation and kinematics, wing ice protection, external lights)

- Landing Gear systems:

On the path to the next generation aircraft, landing gear systems may also be improved quite drastically. The main changes have to be identified in advance and impacts should be investigated at systems level. Moreover, new aircraft configurations may have some major impact on the system design, such as multiple landing capability of the next generation Tiltrotor.

An extensive optimisation environment is expected in order to trade alternative systems versus different landing gear kinematics and operations (e.g. next generation Rotorcraft, E-Taxi, health monitoring...). This environment will include a model of a generic aircraft separate from its landing gear, and a landing gear design environment allowing the efficient exploration of the design space.

- Integrated Cockpit

In the context of WP1 “Extended Cockpit” activities, specific support and expertise are requested to model, simulate and assess different mission environments for different aircraft – large aircraft, regional, business jet, and rotorcraft – using different cockpit layouts or crew configurations.

This integrated cockpit (or cockpits) will be useable to control the simulated flight path and the simulated systems, and shall offer the additional functions described below. For most systems sizing tasks, the cockpit will be capable of jumping the aircraft through a mission using only a few key mission points, and will provide the interpolation laws allowing the remaining fuel to be calculated at each point. Since the models of subsystems are dynamic time domain models, the framework will run short duration simulations around each key point. During such simulations, the integrated cockpit shall be capable of simulating the crew when it executes the required normal, abnormal and emergency procedures. The Core-Partner(s) will propose a method to simulate crew errors in a realistic fashion (for instance based on databases of crew errors which occurred during piloted simulations).

It shall be possible to set up this framework both for a real-time simulation of mission and for faster than real time optimisation tasks.

This calls for different skills and capabilities; it is expected that the successful candidate will act as a value-added partner for WP1 stakeholders as well as a provider of means, tools and environments:

- Provide expertise and proven record of similar activities in other project/programs
- Propose methodologies, relevant criteria, evaluation procedures and base scenarios to assess operational value and human factor benefits of new cockpit concepts in realistic environments.
- Propose tools, methodologies and relevant criteria for crew monitoring, workload analysis, behaviour assessment, ...
- Provide, develop, maintain and make available different environments as described below :
 - Modelling environments: support to early design and transverse approach: cockpit modelling, virtual reality environments.
 - Integration environment : supply of “generic” platform environment to integrate
 - Third party cockpit building blocks: displays, flight controls, keyboards, tactile screens ...
 - software components (FMS, CNS functions, third-party applications, ...)
 - Additional COTS hardware and software: tablets, glasses, video input, voice recognition ...)
 - Evaluation environment : supply of fully simulated mission environment, with
 - Realistic enough aircraft model to power the simulations
 - Landscape, weather simulation capabilities in all flight phases.
 - Capacity to simulate other stakeholders of air transport: ATC, additional traffic, Tower ...
 - Scenario development and execution mode.
 - Crew monitoring and behaviour analysis to assess workload, task sharing, cross-check ... during operational evaluation.

Note 1: due to the variability of the foreseen environments and the impossibility to detail all developments to be developed in WP1, the candidate should indicate basic constraints and organization principles expected: for example hardware platforms (PC or other?), Ethernet messaging, input formats, tools ...

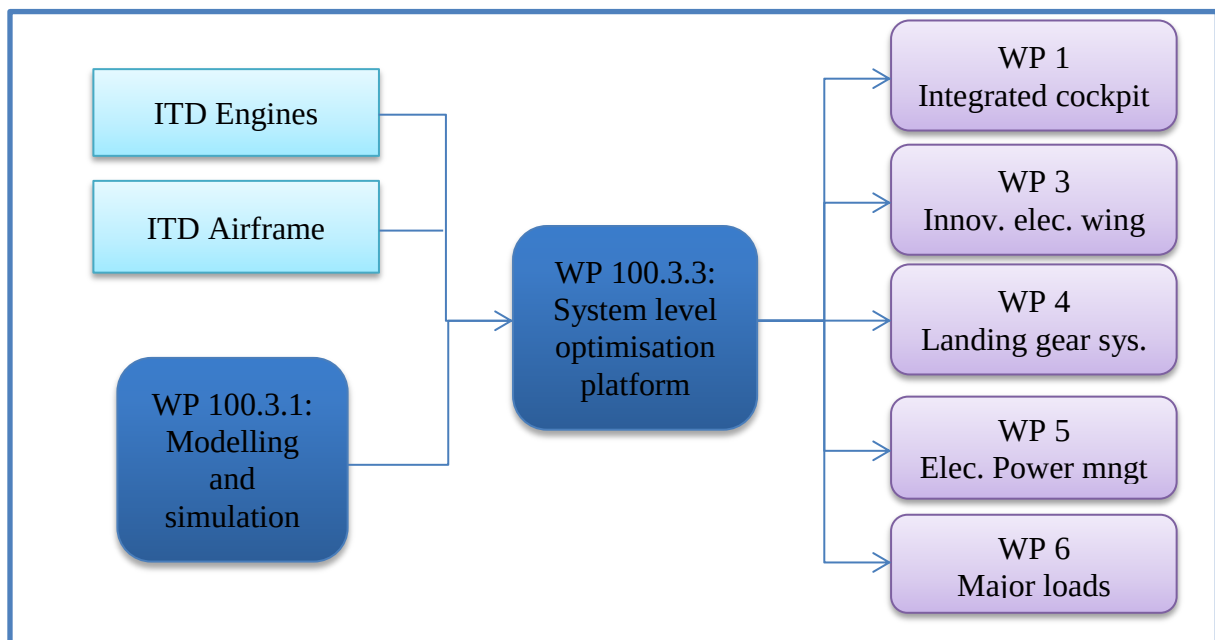
Note 2: as different aircraft segments must be addressed in the offer (large, regional, bizjet, rotorcraft), it is acceptable that distinct environments are proposed by the candidate. However, common tools/methods/environments allowing for a degree of transverse approach, reuse and

common concepts evaluation will be highly appreciated.

Note 3: it is expected that in the answer various costs are expressed:

- Development costs to set up, validate and document the proposed deliverables
- Integration costs
- By-the-hour costs for use of the various environments

Note 4: on a case-by-case basis, to answer unexpected development needs arising from the building blocks to be simulated/integrates/tested, ad hoc CfPs may be considered. The candidate will propose, define and manage these CfPs.



- **WP 100.3.4: Model-based algorithms and controls:**

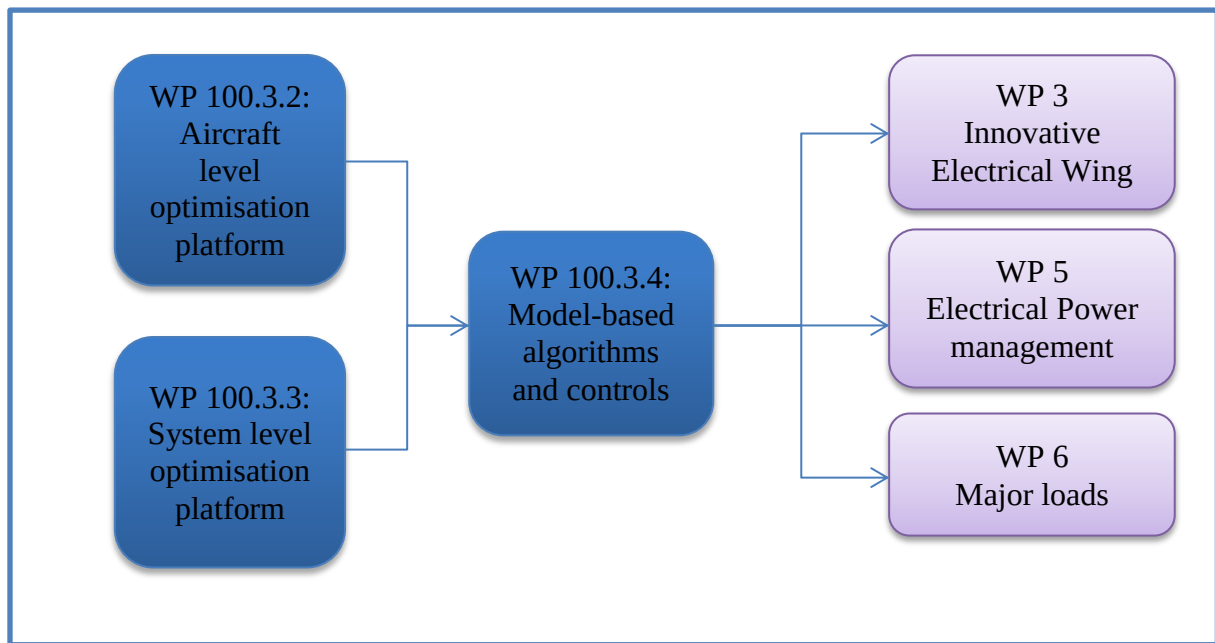
The models used to simulate and to understand the behaviour of various systems on-board the aircraft may be derived to generic control and command algorithms bricks which may then be integrated by the systems manufacturers.

These model-based algorithms may be organised around 4 main technical areas:

- Management functions
- Health Monitoring
- Fault Detection
- Control Methods

Additionally, the automated code generation will be investigated as an enhancement applied to integrated systems.

These different applications will be then evaluated in terms of certification and qualification in a separated activity.



- **WP 100.3.5: Virtual testing:**

The virtual testing for systems is one of the most promising improvement areas in the qualification and certification process. Indeed, the systems designed have to run through highly performant simulations by each of the actors of the supply chain nowadays, but these simulations are not sufficient and have to be completed by a large amount of physical tests and demonstrations.

In the future, we imagine once the systems simulation and modelling environments have been harmonized, some of the physical tests could be replaced by virtual tests, running partially through advanced simulations in order to get the certification of an updated part, or lightly redesigned system.

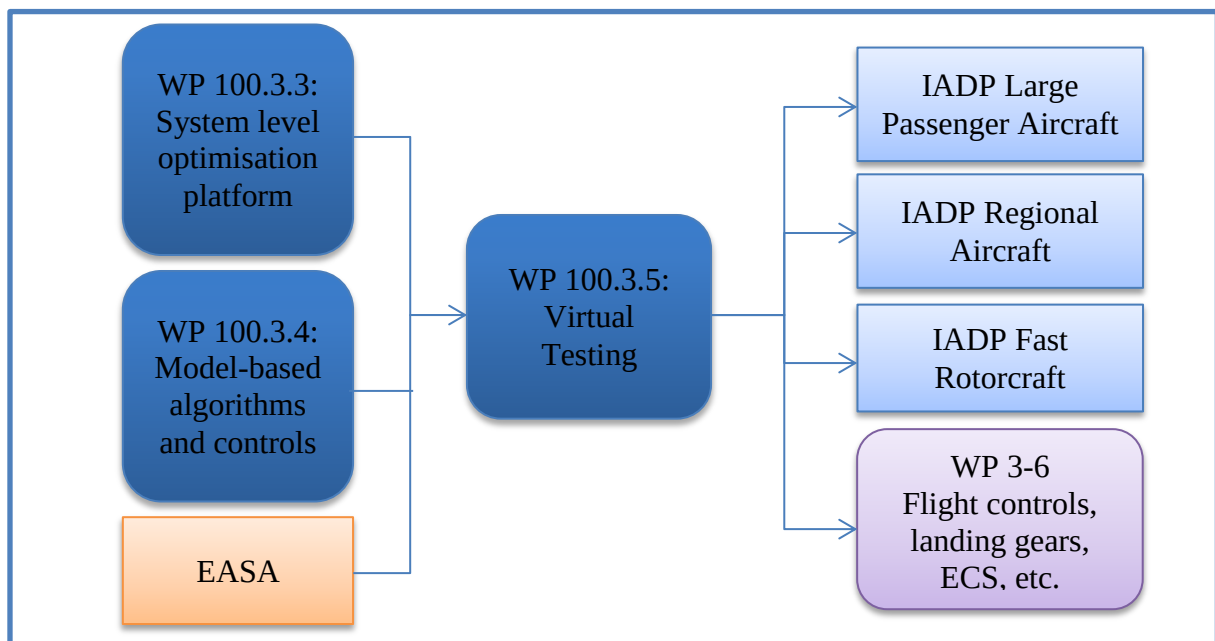
The first stream will investigate the possible methods for virtual testing and the benefits provided by each of these, and also examine how a combination of the different existing methods could lead to satisfying results.

Then, the specific use cases will be derivate to different product categories, focusing a reduced scope

of testing that will be discussed with relevant leaders based on the outcomes of the first studies.

- Flight & Cockpit Simulator
- Electro-Mechanical and Electro-Hydrostatic Actuation
- Electrical Systems
- Environmental Control Systems

The Core-Partner(s) will need to conduct specific discussions with EASA regarding the certificability of systems partially virtually tested.



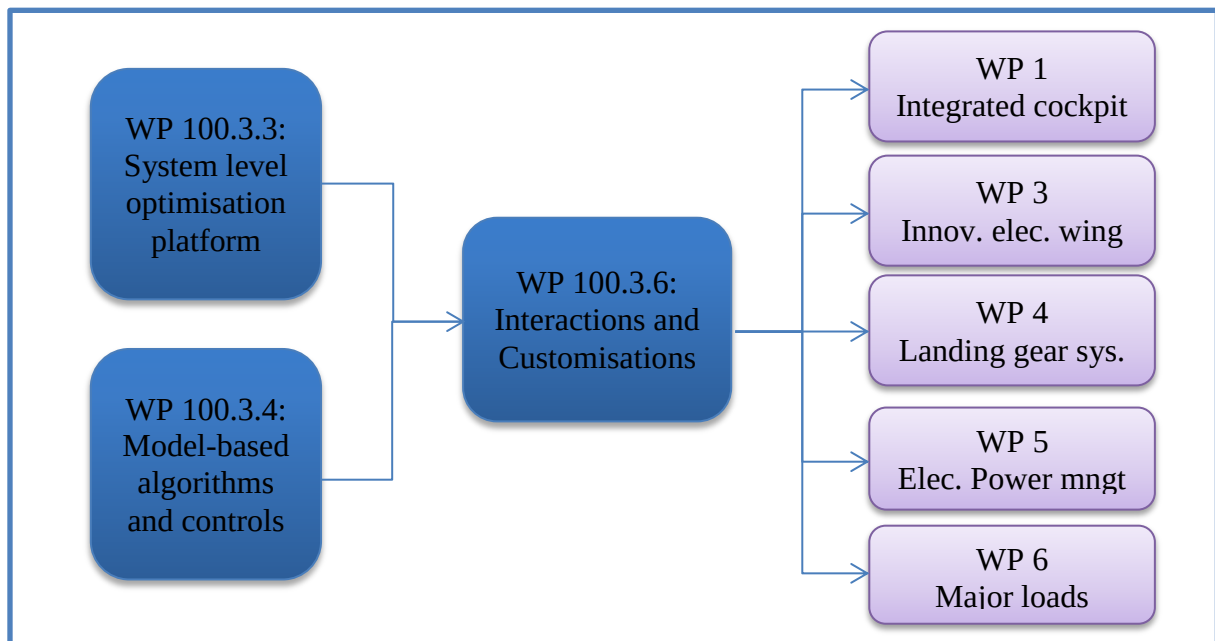
- **WP 100.3.6: Interactions and customisations:**

This activity is ensuring that the relevant information flows are present with the other platforms to guarantee the acceptance of the modelling and simulation environment. A common understanding with the main actors of the aerospace industry is required to develop the expected environments on a neutral basis.

Equally, the Core-Partner(s) will have regular discussions with the Technology Evaluator of Clean Sky 2 in order to ease the use of the models for the evaluation.

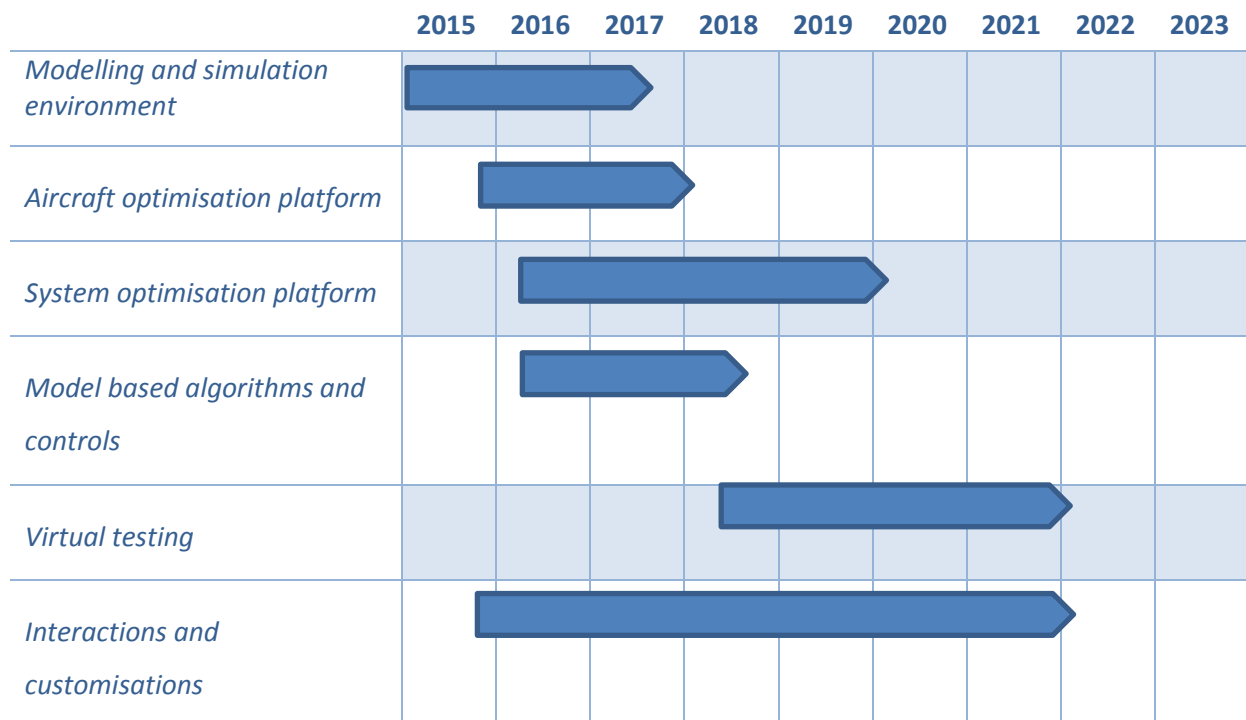
The generic model and simulation environment might need to be customised to the specific need of a demonstration. Therefore, the last work package will focus on this customisation, answering the needs which will be expressed during the program.

These needs will be depending on the provided generic environments and on the specific aspects that will be identified through the maturation of the demonstrators.



- **Overall Planning**

The support activities will be implemented according the following provisional planning:





Topics for Core-Partners Call 1



3. Special skills, capabilities

The required skills to produce highly reliable modelling and simulation environments are various, and cover the full scope of the aircraft systems:

- Model and simulation programming
- Software development methodology and deployed supporting tools
- Aircraft electrical network
- Aircraft systems architecture
- Aircraft thermal architecture
- Wing operations and kinematics
- Landing gears operations and kinematics
- Power management and needs
- Aircraft flight operations
- Aircraft on-ground operations
- Aerospace requirements and certifications
- Cockpit simulation capabilities
- Command and Control algorithms
- Testing procedures in aeronautics

The topic applicants should provide a complete understanding of the aircraft and aircraft operations, with the ability to break down its technical knowledge to the systems level. The experience with various equipment manufacturers and airframers will be a plus, enabling a wide vision and a transversal capability.

In addition, the application must be able to manage a transversal activity high level work package, including the participation to the high level steering committees of the ITD during the program life duration.

Moreover, the selected Core-Partner(s) will have to deal with IP aspects in managing a collaborative work between all actors.

The modelling and simulation activities may require some very specific skills on punctual developments to increase the level of accuracy or to validate a method. The selected Core-Partner(s) should have the capability to manage the launch of Call for Proposals, should its internal skills not reach the targets coming out of the needs definition.

4. Major deliverables and schedule (estimate)

Note: indicative content and dates, to be completed / detailed by the Core-Partner(s)

Deliverables				
Ref. No.		Title - Description	Type	Due Date
100.3.1.1	Core simulation environment	Environment specifications and requirements	Specification	T0 + 6 months
		Product description and integration	Document	T0 + 12m
		Software core environment TRL 3	Demonstrator	T0 + 6m
		Software core environment TRL 4 early adopters deployed	Demonstrator	T0 + 12m
		Software core environment TRL 5 prototype deployed	Demonstrator	T0 + 24m
		Software core environment final version deployed	Demonstrator	T0 + 36m
		Software core environments updated to integrate users feedback	Demonstrator	T0 + 48m
100.3.1.2	Interfaces modules with external tools	List of compatible solutions	Document	T0 + 18m
		Plug-in or methodology for integration	Document	T0 + 24m
100.3.2.1	Aircraft power models for each target platform	List of impacts on systems and selection	Specifications	T0 + 24m
		Model definition for hydraulic power	Document	T0 + 30m
		Model definition for electrical power	Document	T0 + 30m
		Model definition for pneumatic power	Document	T0 + 30m
		Model definition for mechanical power	Document	T0 + 30m
		Combined aircraft models integrating power layers	Demonstrator	T0 + 36m
		Validation of models	Document	T0 + 42m
100.3.2.2	Aircraft thermal models for each target platform	List of impacts on systems and selection	Specifications	T0 + 16m
		Thermal models definition for cabin & cargos	Document	T0 + 22m
		Thermal models definition for components	Document	T0 + 22m
		Combined aircraft models integrating thermal layers	Demonstrator	T0 + 28m

Deliverables				
Ref. No.		Title - Description	Type	Due Date
		Validation of models	Document	T0 + 34m
100.3.2.3	Aircraft operations model	List of impacts on systems and selection	Specifications	T0 + 16m
		Aircraft in-flight operations model	Document	T0 + 22m
		Basic aircraft in-flight operations model	Demonstrator	T0 + 24m
		Aircraft on ground operations model	Document	T0 + 30m
		Combined aircraft models integrating operations	Demonstrator	T0 + 36m
		Validation of models	Document	T0 + 42m
100.3.2.4	Collections of simplified models adapted to different platforms and technological issues	Identification of simplification targets (models and datasets)	Specifications	T0 + 18m
		Collections of simplified models adapted to different platforms and technological issues	Demonstrator	T0 + 30m
		First yearly synthesis of Benchmarking of simplified models versus original in the available system architecture models.	Document, with yearly updates	T0 + 42m
		Synthesis of model simplification activities	Document	T0 + 48m
100.3.3.1	Electrical architecture model	Requirements and Specifications	Specifications	T0 + 36m
		System architecture modelling	Demonstrator	T0 + 48m
		Validation and benchmarking of the model	Document	T0 + 54m
100.3.3.2	Thermal architecture	Requirements and Specifications	Specifications	T0 + 36m
		System architecture modelling	Demonstrator	T0 + 48m
		Validation and benchmarking of the model	Document	T0 + 54m
100.3.3.3	Wing systems	Requirements and Specifications	Specifications	T0 + 18m
		System architecture modelling	Demonstrator	T0 + 30m
		Validation and benchmarking of the model	Document	T0 + 42m
100.3.3.4	EMA & EHA actuation	Requirements and Specifications	Specifications	T0 + 6m
		System architecture modelling	Demonstrator	T0 + 12m

Deliverables				
Ref. No.		Title - Description	Type	Due Date
	systems models	Validation and benchmarking of the model	Document	T0 + 18m
100.3.3.5	Cockpit Modelling environments	Description of proposed environment(s). Performance, benefits, interface, evaluation tools	Specification	T0+6m
		List of available objects, functions, methods. Development manual for additional 3rd-party components	Documents	T0+6m
		Physical environments	Demonstrators	T0+18m
100.3.3.6	Cockpit Integration environment(s)	Description of generic environment : architecture, content, extensibility, interface constraints	Documents	T0+18m
		Integration environment	Demonstrator	T0+30m
100.3.3.7	Cockpit Evaluation environment(s)	General description of evaluation environment, assessment tools, scenario definition and execution	Document	T0+30m
		Evaluation environment	Demonstrator	T0+36m
100.3.4.1	Health Monitoring and Fault Detection models	Specifications	Specifications	T0 + 36m
		Model for simulation	Demonstrator	T0 + 48m
		Validation	Document	T0 + 54m
100.3.4.2	Control and Management functions	Specifications	Specifications	T0 + 24m
		Model for simulation	Demonstrator	T0 + 36m
		Validation	Document	T0 + 48m
100.3.5	Virtual Testing	Virtual testing methods definition	Specifications	T0 + 18m
		Feasibility and Eligibility for certification	Document	T0 + 48m
		Results of hardware in the loop vs. full virtual tests	Demonstrator	T0 + 60m
		Validation and certification	Document	T0 + 66m
100.3.6	Customisation to ITD Systems Demonstrators	Various customised models fitting to demonstrators needs	Demonstrator	T0 up to program end

5. Definition of terms

- **Flight physics FLP**

CFD Computational Fluid Dynamics

ENP External Noise prediction

- **Aircraft Avionics, Systems & Equipment AVS**

CSD Cockpit Systems, Visualisation & Display Systems

NAV Navigation / Flight Management / Autoland

EME Electronics & Microelectronics for on-board systems

SIN Sensors integration

FDR Flight Data/Flight Recording

CSY Communications Systems

AVI Avionics Integration

HUM Aircraft health and usage monitoring system

SMA Smart maintenance systems

EPG Electrical Power Generation & Distribution

PNU Pneumatic systems

HYD Hydraulic power generation & distribution

ECS Environmental control System

LGB Landing gear and braking systems

- **Flight Mechanics FLM**

FCS Flight control system

APS Aircraft Performance Analysis

OAP Optimisation of Aircraft Performance

- **Integrated Design & Validation (methods & tools) IDV**

ITC Methods and IT tools for Collaborative Development

OSE On-board Systems Engineering

SYC System Certification

REL System reliability

MMO Maintenance modelling

SEV Simulator environments & Virtual reality

ORM Development of operational research methods & tools

DSV Development of synthetic environment & virtual reality

ACP Aircraft Performance Assessment

NUM Numerical Models (including Fast Time Simulation)

RTS Real Time Simulators

- **Human Factors HFA**

HFI Human Factors Integration, Man-machine Interface

HIP Human Information Processing

HPM Human Performance Modelling & Enhancement

- **Innovative Concepts & scenarios ICS**

SCE Scenarios analysis