Clean Sky Joint Undertaking
Call SP1-JTI-CS-2013-03

European Commission
Research Directorates

Call for Proposals:

CLEAN SKY
RESEARCH and TECHNOLOGY DEVELOPMENT PROJECTS
(CS-RTD Projects):

Call Text

Call Identifier
SP1-JTI-CS-2013-03

Index

Document change log

Date	*Topics Impacted*	*Description*

Specialised and technical assistance:

CORDIS help desk http://cordis.europa.eu/guidance/helpdesk/home_en.html

For questions about the proposal submission system Contact:

DIGIT-EFP7-SEP-SUPPORT@ec.europa.eu

Tel: +32(2) 29 92222

For Questions about Intellectual Property Rights:

IPR help desk http://www.ipr-helpdesk.org

Introduction

Via the Calls for Proposal, Clean Sky aims to incorporate Partners to address very specific tasks which fit into the overall technical Work Programme and time schedule.

Due to the nature of these tasks, the Call is not set up using a set of themes, but it is conceived as a collection of very detailed Topics. The Call text therefore consists of a set of topic fiches, attached here.

Each Topic fiche addresses the following points:

- Topic manager (not to be published)
- Indicative start and Indicative End Dates of the activity
- Description of the task
- Indicative length of the proposal (where applicable)
- Specific skills required from the applicant
- Major deliverables and schedule
- Maximum Topic Budget value
- Remarks (where applicable)

The maximum allowed Topic budget relates to the total scope of work. A Maximum funding is also indicated. The topic value represents an eligibility criterion for the proposal

Depending on the nature of the participant, the funding will be between 50% and 75% of the Topic maximum budget indicated. It has to be noted that the Topic budget excludes VAT, as this is not eligible within the frame of Clean Sky.

The proposal value must be within the threshold of the topic!

Proposal Submission Forms

EUROPEAN COMMISSION
7 th Framework Programme for Research, Technological Development and Demonstration

Collaborative Project

CLEANSKY

A3.2: Budget

Proposal Number: nnnnnn
Proposal Acronym: yyyyyyyyyy

Participant number	Organisation short name	Country	Estimated budget (whole duration of the project) RTD	Demonstration	Management	Other	TOTAL	Total receipts	Requested JU contribution
1	zzzzzzzzz	CH	564 286	0	35 714	0	600 000	0	450 000
TOTAL			564 286	0	35 714	0	600 000	0	450 000

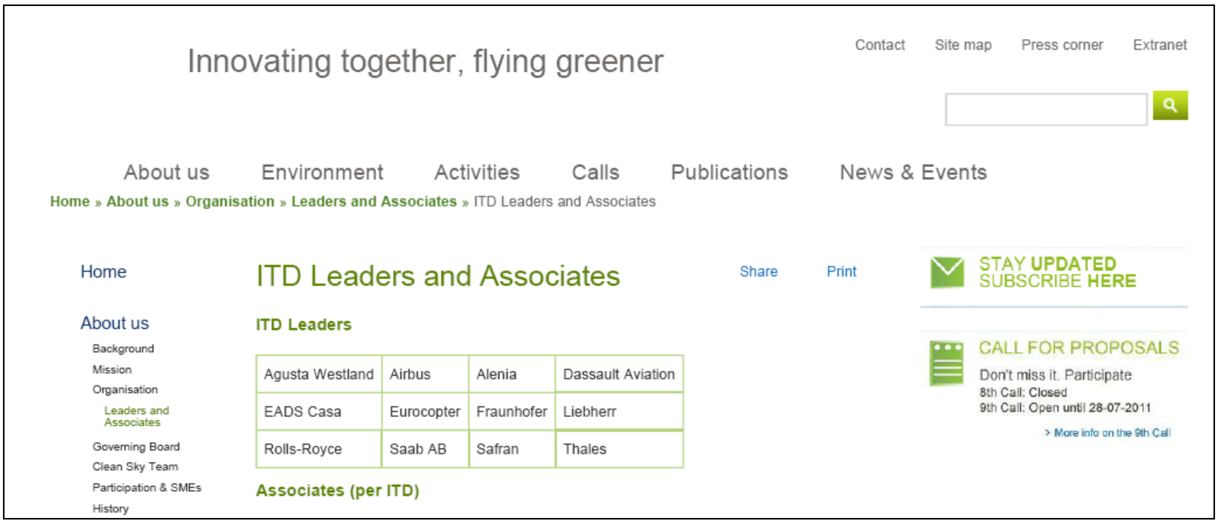
Make sure this total amount is below the value of the topic!!
Better, keep at least 5% margin below to be sure.
Final amount is to be discussed in the negotiation.

Other Eligibility criteria

All applicants are requested to verify their actual status of "**affiliate**" with respect to the members of the relevant ITD for whose topic(s) they wish to submit a proposal. Applicants who are affiliated to any leader or associate of an ITD will be declared not eligible for the topics of that ITD.

Refer to art.12 of the Statute (*Council Regulation (EC) No 71/2007 of 20 December 2007 setting up the Clean Sky Joint Undertaking*) and to page 8 of the Guidelines.

Please check on the Clean Sky web site the composition of the ITDs in the dedicated page:



Recommendation to applicants:

In case of deviations from the requirements of the topic (in terms of deadlines, number and type of deliverables, and so on), please state it at the beginning of your proposals as a Caveat, explaining the reasons and justifications for your choice.

You have to clarify your way of compliance with the topic at start of document, in order to properly prepare the evaluation.

Evaluation

Thresholds:

As indicated in section 4.6 of the *"Rules for Participation and Rules for Submission of Proposals and the related Evaluation, Selection and Award Procedures"*, each proposal will be evaluated on 6 criteria.

For a Proposal to be considered for funding, it needs to pass the following thresholds:

- **Minimum 3/5** score for each of the 6 criteria,
  AND
- **Minimum 20/30 total score**

Only one Grant Agreement (GA) shall be awarded per Topic.

Calendar of events:

- **Call Launch: 19 December 2013**
- **Call close: 03 April 2014, 17:00 Brussels time**

- Evaluations (indicative): 12-16 May 2014

- Start of negotiations (indicative): 19 June 2014
- Final date for signature of GA by Partner: 11 July 2014
- Final date for signature of GA by Clean Sky JU: 31 July 2014

Recommendation to get a PIC

The applicant is encouraged to apply for a PIC (Participant Identity Code) and to launch the process of validation as early as possible; this will speed up the process of negotiation in the event that your proposal is successful (see http://cordis.europa.eu/fp7/pp-pic_en.html)

Contacts:

All questions regarding the topics published in this Call can be addressed to:

info-call-2013-03@cleansky.eu

Questions received until **28 February 2014** will be considered.

A first version of the Q/A document will be released by **14 February 2014**.

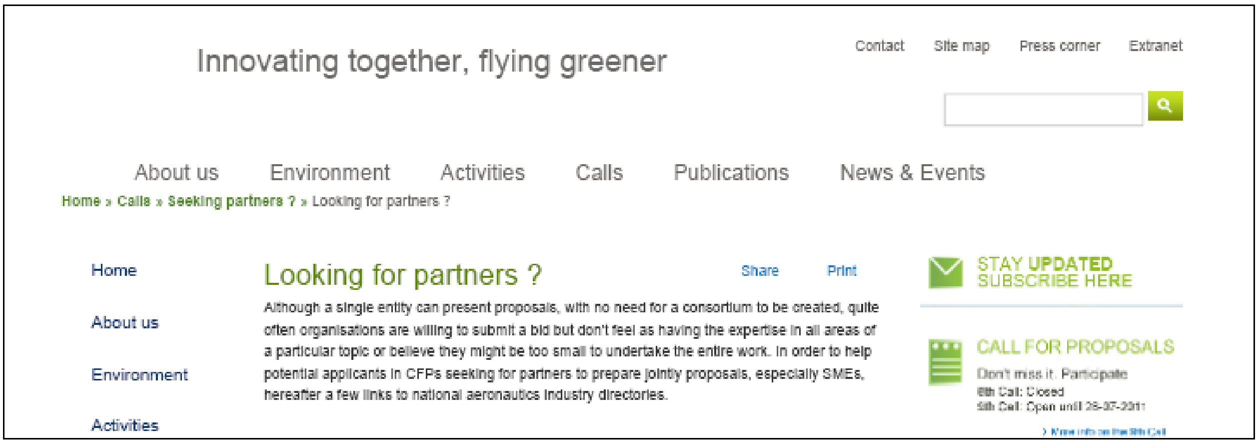
The final version of the Q/A document will be released by **14 March 2014**.

Questions having a general value, either on procedural aspects or specific technical clarifications concerning the call topics, when judged worth being disseminated, will be published in a specific section of the web site (www.cleansky.eu), together with the answers provided by the topic managers.

All interested applicants are suggested to consult periodically this section, to be updated on explanations being provided on the call content.

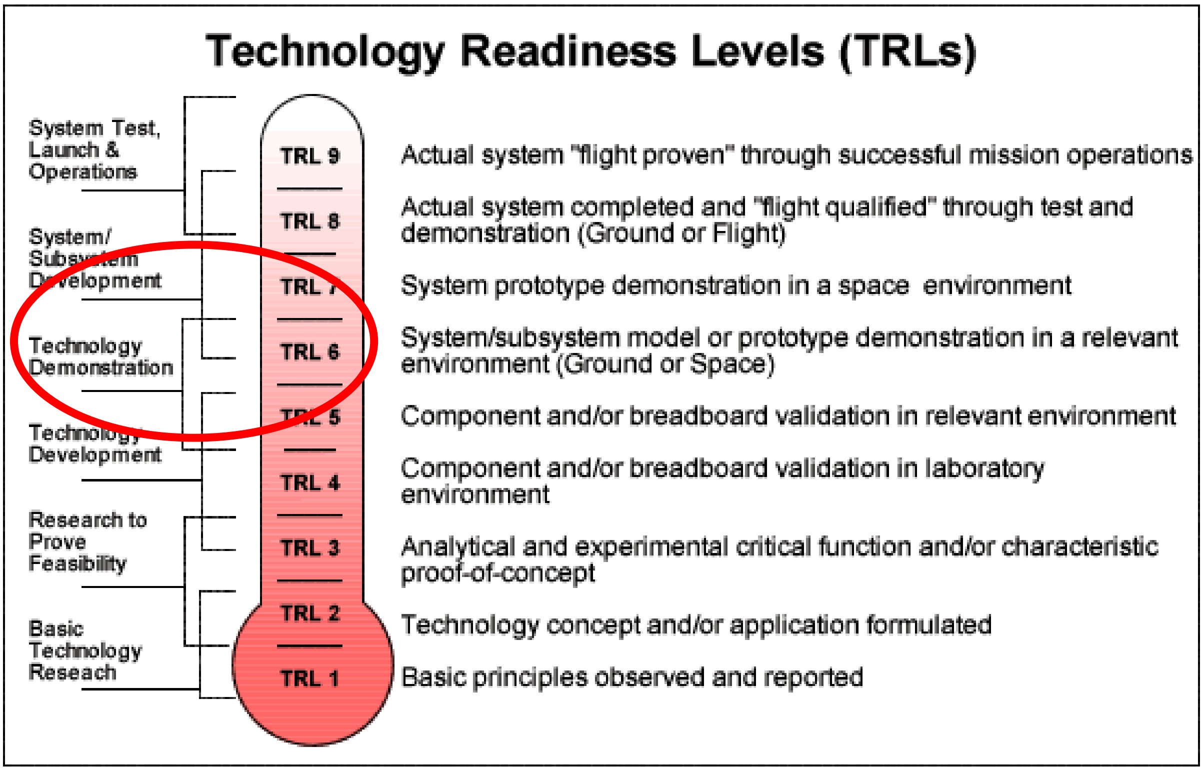
Looking for Partners?

If you are interested in checking available partners for a consortium to prepare a proposal, please be aware that on the Clean Sky web site there is a specific area with links to several databases of national aeronautical directories:



Reference to TRL:

When applicable or quoted in the text of topics, the applicants should be aware of the definition of Technology Readiness Levels, as per following chart, being TRL 6 the target for Clean Sky for all applicable technologies:



Topic list table

Identification	ITD - AREA - TOPIC	topics	VALUE (€)	MAX FUND (€)
JTI-CS-SAGE	**Clean Sky - Sustainable and Green Engines**	**9**	**9.750.000**	**7.312.500**
JTI-CS-SAGE-01	*Area-01 - Open Rotor Demo 1*		**0**	
JTI-CS-SAGE-02	*Area-02 - Open Rotor Demo 2*		**2.900.000**	
JTI-CS-2013-03-SAGE-02-037	Innovative instrumentation for rotating gauges		350.000	
JTI-CS-2013-03-SAGE-02-038	Effect of tolerance variation in high power density gears		600.000	
JTI-CS-2013-03-SAGE-02-039	High Speed Turbine Powder Hipping Casing		900.000	
JTI-CS-2013-03-SAGE-02-040	Non-intrusive Turbine Blade measurements		1.050.000	
JTI-CS-SAGE-03	*Area-03 - Large 3-shaft turbofan*		**1.750.000**	
JTI-CS-2013-03-SAGE-03-024	Electric Pump for Safety Critical Aero engine applications		1.750.000	
JTI-CS-SAGE-04	*Area-04 - Geared Turbofan*		**0**	
JTI-CS-SAGE-05	*Area-05 - Turboshaft*		**0**	
JTI-CS-SAGE-06	*Area-06 - Lean Burner*		**5.100.000**	
JTI-CS-2013-03-SAGE-06-008	Instrumentation Capability for Accelerated Lean Burn development		2.150.000	
JTI-CS-2013-03-SAGE-06-009	Advanced methods for prediction of lean burn combustor unsteady phenomena		950.000	
JTI-CS-2013-03-SAGE-06-010	Smart methods for lean burn injector design		500.000	
JTI-CS-2013-03-SAGE-06-011	Design methods for accurate combustor wall temperature		1.500.000	
JTI-CS-SFWA	**Clean Sky - Smart Fixed Wing Aircraft**	**10**	**7.615.000**	**5.711.250**
JTI-CS-SFWA-01	*Area01 – Smart Wing Technology*		**1.200.000**	
JTI-CS-2013-03-SFWA-01-054	MEMS Accelerometer – Miniaturisation of the analog electronics in ASIC(s)		800.000	
JTI-CS-2013-03-SFWA-01-055	Miniaturization of digital processing function for a MEMS pendulous accelerometer		400.000	
JTI-CS-SFWA-02	*Area02 - New Configuration*		**1.845.000**	
JTI-CS-2013-03-SFWA-02-044	NLF Wing High Speed Performance Test		1.500.000	
JTI-CS-2013-03-SFWA-02-045	Camera Development for In-Service Monitoring of LE Contamination		145.000	
JTI-CS-2013-03-SFWA-02-046	In-service monitoring of Leading Edge Contamination and Damage		200.000	
JTI-CS-SFWA-03	*Area03 – Flight Demonstrators*		**4.570.000**	
JTI-CS-2013-03-SFWA-03-015	Jigs and Fixtures for Assembly of the Laminar Wing at the "BLADE" Flight Dest Demonstrator Final Assembly Line		900.000	
JTI-CS-2013-03-SFWA-03-016	Wing Tooling for the BLADE Flight Test Demonstrator Final Assembly Line		300.000	
JTI-CS-2013-03-SFWA-03-017	In-Flight Local Surface Deformation Measurements by Means of Reflectometry and Shadow Casting		640.000	
JTI-CS-2013-03-SFWA-03-018	Design, Manufacturing, Qualif.& Assy of an improved NLF Wing LE & Upper Cover Flight Test Article		2.200.000	
JTI-CS-2013-03-SFWA-03-019	Miniaturized remote acquisition unit for optical sensors		530.000	
JTI-CS-SGO	**Clean Sky - Systems for Green Operations**	**11**	**6.290.000**	**4.717.500**
JTI-CS-SGO-01	*Area-01 - Definition of Aircraft Solutions and explotation strategies*		**0**	
JTI-CS-SGO-02	*Area-02 - Management of Aircraft Energy*		**4.640.000**	
JTI-CS-2013-3-SGO-02-052	Electrical Starter / Generator disconnect system		600.000	
JTI-CS-2013-3-SGO-02-066	HVDC fuses design, development, validation and integration		800.000	
JTI-CS-2013-3-SGO-02-083	Adaptable power density coating for energy efficient heating of cockpit and cabin		1.000.000	
JTI-CS-2013-3-SGO-02-084	Optimizing power density of aircraft inverter by combining topology and PWM-patterns		500.000	
JTI-CS-2013-3-SGO-02-085	Development of a composite sleeve for spatial separation of rotor and stator of an electrical motor		300.000	
JTI-CS-2013-3-SGO-02-086	Development of actuator components made by alternative metal injection molding (MIM) process		200.000	
JTI-CS-2013-3-SGO-02-087	Technology development and fabrication of high-temperature high-frequency capacitors for power switch integration		440.000	
JTI-CS-2013-3-SGO-02-088	Accelerated Life Testing of Electrical Motor Drives		800.000	
JTI-CS-SGO-03	*Area-03 - Management of Trajectory and Mission*		**200.000**	
JTI-CS-2013-3-SGO-03-027	Provision of a cross platform development tool suite for high performance computing on tablet platforms		200.000	
JTI-CS-SGO-04	*Area-04 - Aircraft Demonstrators*		**1.450.000**	
JTI-CS-2013-3-SGO-04-006	Thermal Mock-ups for Thermal Management of a Ground Integration Test Rig		1.200.000	
JTI-CS-2013-3-SGO-04-010	Air Distribution assembly for EECS flight test demonstration		250.000	
JTI-CS-TEV	**Clean Sky - Technology Evaluator**	**0**	0	0,000
		topics	**VALUE**	**FUND**
	totals	**30**	**23.655.000**	**17.741.250**

Clean Sky – Eco Design

No topics for ECO

Clean Sky – Green Regional Aircraft

No topics for GRA

Clean Sky – Green Rotorcraft

No topics for GRC

Clean Sky – Sustainable and Green Engines

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JTI-CS-2013-03-SAGE-02-040	Non-intrusive Turbine Blade measurements		1.050.000	
JTI-CS-SAGE-03	*Area-03 - Large 3-shaft turbofan*		**1.750.000**	
JTI-CS-2013-03-SAGE-03-024	Electric Pump for Safety Critical Aero engine applications		1.750.000	
JTI-CS-SAGE-04	*Area-04 - Geared Turbofan*		**0**	
JTI-CS-SAGE-05	*Area-05 - Turboshaft*		**0**	
JTI-CS-SAGE-06	*Area-06 - Lean Burner*		**5.100.000**	
JTI-CS-2013-03-SAGE-06-008	Instrumentation Capability for Accelerated Lean Burn development		2.150.000	
JTI-CS-2013-03-SAGE-06-009	Advanced methods for prediction of lean burn combustor unsteady phenomena		950.000	
JTI-CS-2013-03-SAGE-06-010	Smart methods for lean burn injector design		500.000	
JTI-CS-2013-03-SAGE-06-011	Design methods for accurate combustor wall temperature		1.500.000	

Topic Description

CfP topic number	Title		
JTI-CS-2013-03-SAGE-02-037	***Innovative instrumentation for rotating gauges***	**Start date**	*T0*
		End date	*T0+10*

1. Topic Description

Aeronautical market evolution is focusing on mechanical transmissions as evidenced by the current fruitful research on the next generation engine (geared turbofan, open rotor, tilting rotor, …).

Open Rotor geared engine is a promising architecture for future aeronautical market due to significant reduction opportunities in fuel consumption compared to conventional engines.

The purpose of Geared Open Rotor demonstrator (SAGE 2) as part of the Sustainable and Green Engine (SAGE) platform is to advance the enabling technologies to achieve the necessary knowledge and validation.

The Geared Open Rotor architecture introduces a decoupling between the turbomachine speed and the propellers speeds to allow separate optimization of both systems, with overall efficiency gain of the whole engine, through the use of a Power Reduction Gearbox (PGB). Power Transmissions therefore enable this low emission novel engine architecture and represent a new core module.

Target applications require design solutions for very high power density. In addition, revolutionary configurations like Open Rotor integrate the PGB in a very demanding temperature environment.

The maximum temperature achieved depends on the location. Consider temperature of about 200°C as a reference. The applicant is requested to provide temperature limitation for each sensor type even if exceeding the reference temperature. It shall be taken into account that both the rotating and static hardware will operate in an oil mist environment (oil is per Spec MIL-PRF-23699).

The innovative technologies implemented on components and modules have to be matured in order to ensure a low risk introduction on the demonstrator.

There is the need of exploring the possibility of apply latest available instrumentation (e.g. optical strain gauges, rotating acquisition systems, non-contact measurement) to maximize both learning from revolutionary application testing and design verification opportunities.

In order to answer the needs of the SAGE 2 in terms of research, technological development and demonstration activities, it is planned to offer individual task to the industry, universities or any legal entity. The present Call for Proposal supports the identification and implementation of innovative/advanced instrumentation into the Power Reduction Gearbox designed by the Topic Manager (SAGE 2, Work Package 2.2.8).

The partners work includes the following tasks:

Task 1: Innovative Instrumentation Scouting (T0 – T0+4)

At the kick-off of the present Project, the Topic Manager will provide to the Applicant the final instrumentation list.

A rough estimation of the measure type and quantity (including spares) is reported in the table below:

Mesure Type	Tot Q.ty Static	Tot Q.ty Rotating
Vibe	10	-
Proxy	10	-
Air Press	15	-
Air Temp	20	-
Metal Temp	20	10
Oil Temp	5	3
Oil Press	5	-
Oil Flow	3	-
Strain gauge	-	10
Microphone	3	-
Oil Chip Detector	3	-
Total	94	23

Based on the definition of reference application(s) and relevant instrumentation requirements for the Power Gearbox (Applicant in conjunction with Topic Manager) a scouting of the potential solutions will be proposed by the Applicant.

The main areas of interest are:

- strain measurement of gear body, gear teeth and structural rotating parts (about 1000rpm);
- metal temperature measurement of gear body, gear teeth and bearing races;
- on-line oil analysis for oil degradation monitoring (e.g. rotating oil pressure transducers) and indirect monitoring of transmission health status;
- noise & vibration measurements (accelerometers and/or internal cavity microphones to be evaluated)

The Applicant will identify and suggest potential solutions including system/sensors innovative and/or state of the art technology already used in other applications to be properly adapted.

The instrumentation proposal will be assessed during a dedicated Review by the Topic Manager through specific scorecards, and further shared with the SAGE2 Coordinator, to guarantee the potential feasibility of the integration into the Ground Demo Engine.

Based on the proposal and on the critical assessment made by the involved actors, the suitable instrumentation solutions will be selected.

The potential need of detailed Technology Maturation for some of the selected instrumentation solutions will be one of the parameters to be assessed (e.g. validation tests in harsh environment such as MIL-PRF-23699 oil and hot temperature).

The Applicants should define detailed Technology Development Plans in order to guarantee and demonstrate the enough TRL of the proposed solutions (at least TRL5), to reduce the risk at an acceptable level and to guarantee the respect of the proposed project schedule.

Task 2: Instrumentation Procurement and Validation (T0+4 – T0+10)

Based on the down-selected instrumentation (Task 1 final output), the Applicant will be responsible for the procurement of instrumentation prototypes for application during gearbox test on opportunity basis, and of the Technology Maturation process, if needed.

In case of Technology Maturation needs, the Applicant should define a detail development process of the product, to be shared and assessed with the Topic Manager, guarantying full evidence of the TRL progress. Dedicated test campaign will be run by the applicant to mature the TRL for the identified innovative technologies. The Topic Manager will support the Applicant in the validation phase assessing the possibility to test the proposed innovative instrumentation in the already available Test Facilities.

A proposal of amount of the budget that will be allocated to the procurement of instrumentation prototypes has to be presented by Applicant when replying to this Call.

The instrumentation to be implemented in the SAGE 2 Ground test Demo is intended to be provided only, while its application will be performed by the Topic Manager.

2. Special skills, certification or equipment expected from the applicant

Special Skills:

Extensive and proven experience in enhanced sensors (e.g. non-contacting measurement techniques), for aerospace / transmission systems products, design, validation and manufacturing is mandatory.

Availability of technologies at a high readiness level to minimize program risks is an asset.

The Applicant needs to demonstrate to be in the position to have access to the test facilities required to meet the Topic goals; otherwise the Topic Manager will support the validation phase (in the second option a reduced cost provision with respect to the defined Topic Budget is expected).

Experience in Supply Chain management is mandatory.

Experience in aerospace R&T and R&D programs is a benefit.

The activity will be managed with a Phase & Gate approach and management plan has to be provided. Topic Manager will approve gates and authorize progress to subsequent phases.

Technical/program documentation, including planning, drawings, design reports, risk analysis, FMEA, test plan and test requirements, test results, test analysis reports must be made available to Topic Manager.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1.1	Potential Instrumentation Solution Down Selection	Critical assessment and down selection of scouted possible innovative solutions.	T0+4
D1.2	Technologies Maturation Plan	Detail technologies maturation plan for innovative technologies (if needed)	T0+5
D2.1	Final instrumentation List	Final instrumentation list, based on technology development output (if needed) or back-up solution choosing	T0+10
Milestone	**Title**	**Description (if applicable)**	**Due date**
M1.1	Instrumentation Requirements Definition	Definition of reference application(s) and relevant instrumentation requirements (Topic Manager in conjunction with Applicant)	T0+1
M1.2	Potential Instrumentation Solution Down Selection	Emission of D1.1 & D1.2 End of Task 1	T0+4
M2.1	Prototype Instrumentation Procurement	All Instrumentation to be validated available	T0+7
M2.2	Demo Instrumentation Procurement	All PGB Instrumentation for the SAGE 2 Ground Test Demo available	T0+10

4. Topic value (€)

350,000 €

[three hundred fifty thousand euro

The proposed topic value is a maximum gross value for the proposed activity.

5. Remarks

The proposal of the applicant has to include maximal realizable values for every given requirement. A detailed work plan and time schedule is being expected. A profound financial plan must be attached as well. The applicant must fulfil the above mentioned requirements.

Topic Description

CfP topic number	Title		
JTI-CS-2013-03-SAGE-02-038	***Effect of tolerance variation in high power density gears***	**Start date**	*T0*
		End date	*T0+12*

1. Topic Description

Aeronautical market evolution is focusing on mechanical transmissions (Geared Turbo Fan, Open Rotor, next generation Turboprop, Tilting Rotor). Geared engines configurations are promising architectures due to significant reduction opportunities in fuel consumption compared to conventional turbofan engines.

These architectures introduce a decoupling between the turbomachine speed and the propeller(s) speed(s) to allow separate optimization of both systems, with overall efficiency gain of the whole engine, through the use of a Power reduction Gearbox (PGB). Power Transmissions therefore enable these low emission engine architectures and represent a core module.

A PGB design critical to quality is high power density, associated to high operative speeds. Today design definition is increasing product robustness by taking into account effect of manufacturing tolerances. This is of particular interest for hyperstatic conditions, which may be very sensitive to variations. In order to further validate design solutions for the PGB Module, the usage of a dedicated Design of Experiments (DOE) approach has been identified in support of specialized calculation tools.

The present Topic supports aims at performing dedicated experimental DOE.

The Applicant work includes the following tasks:

Task 1: Test Plan Definition (M0 – M2)

Task 1 covers the definition of an experimental test campaign supporting DOE approach validation.

The test campaign detail requirements will be shared by the Topic Manager to the Applicant, based on definition of reference geometry for the Test Articles (2 tooth geometries, spur gears), the expected output and the identified influencing factors, in order to assess and agree a DOE, based on which the Test Plan will be proposed by the Applicant.

For reference, the baseline DOE is: full factorial, 4 X's at 2 levels.

The X's parameters will be defined by the Topic Manager and agreed with the Applicant (M1.1 Test Campaign Requirements Specification), one parameter being the pressure angle and the others being representative of the manufacturing tolerances.

Task 2: Test Articles Procurement (M1 – M6)

Task 2 covers the Test Articles procurement. Based on the agreed Test Plan and on the reference geometry for the Test Articles (issued by the Topic Manager) the Applicant will be responsible for:

- Manufacturing drawing(s) preparation
- Raw Materials procurement (material specification and quality control on Raw Materials to be supported by the Topic Manager)
- Test Articles machining
- Test Article heat treatment.

Task 3: Test Campaign & Results wrap-up (M3 – M12)

Task 3 covers the Test Campaign execution and results data analysis. Based on the agreed Test Plan and on the reference geometry for the Test Articles, the Applicant will be responsible for the Test Campaign, which includes:

- Rig Test adaptation (if needed), based on the Test Articles specification and on the Test Campaign definition
- Rig Test Commissioning

- Test Campaign (based on detailed Test Plan)
- Result wrap-up.

In particular the following effects (Y's) should be considered:

a) load capacity (contact pressure, root bending stress)
b) teeth wear (pitting, scoring/scuffing)
c) noise (transmission error)
d) power losses

Test results shall be made available to the Topic Manager as long as they have been accrued and validated.

The validation of the design has to be done by component (gear) testing, aiming at testing on a power recirculating rig a set of gear pairs, that will differ for a number of macro and micro-parameters in order to implement the identified DOE (see also Task 1 description).

The experiment expected output is twofold:

- one output is represented by measured data to assess meshing behaviour like accelerations, noise, heat rejection
- one output is represented by mechanical condition report at the end of the test session.

2. Special skills, certification or equipment expected from the applicant

Necessary Equipment:

- Power Recirculating Rig for gear component testing (bending, pitting, scuffing).

Equipment has to be already commissioned and general description has to be presented by Applicant when replying to this Call.

Special Skills:

- Experience in gear design and LTCA (for T/As design)
- Experience in Supply Chain management (for T/As procurement)
- Experience in experimental testing and Statistical Methodologies (for Test Plan definition and execution).

The activity will be managed with a Phase & Gate approach and management plan has to be provided. The topic manager will approve gates and authorize progress to subsequent phases.

Technical/program documentation, including planning, drawings, design reports, risk analysis, FMEA, test plan and test requirements, test results, test analysis reports must be made available to the topic manager

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1.1	Test Plan Definition	Detailed test plan definition, based on agreed DOE and identifying needed Test Articles	T0+2
D2.1	Test Articles Procurement Report	Report on the procured TAs	T0+6
D3.1	Results wrap-up	Experimental DOE validated results	T0+12
Milestone	**Title**	**Description (if applicable)**	**Due date**
M1.1 (under Topic manager Responsibility)	Test Campaign Requirements Specification	Definition of reference geometry, output and influencing factors, and design of experiment (Topic Manager)	T0+1

M1.2	Test Plan Definition	Emission of D1.1 End of WP1	T0+2
M2.1	Test Articles Procurement	Test Articles availability End of WP2	T0+6
M3.1	End of Test Campaign	End of experimental campaign	T0+10
M3.2	Final results wrap-up	Emission of D3.1 End of WP3	T0+12

4. Topic value (€)

600,000 €
[six hundred thousand euro]

The proposed topic value is a maximum gross value for the proposed activity.

5. Remarks

The proposal of the applicant has to include maximal realizable values for every given requirement. A detailed work plan and time schedule is being expected. A profound financial plan must be attached as well. The applicant must fulfil the above mentioned requirements.

Topic Description

CfP topic number	Title		
JTI-CS-2013-03-SAGE-02-039	***High speed turbine casing produced by powder HIP technology***	**Start date**	*T0*
		End date	*T0+12*

1. Topic Description

A turbine casing is the outer stationary part of the turbine designed to withstand stresses at high temperature and to be stiff enough in order to maintain accurate clearances between the stationary and rotating parts.

Nowadays the materials used for producing casings are Nickel-based superalloys (eg. Waspaloy) obtained by forging process and consequentially machined, that is a very expensive operation and involves an inefficient use of high-tech material.

Net Shape Hot Isostatic Pressing is a well-established technique for consolidating metal powder to full density using heated gas under very high pressure.

It is a manufacturing process which can provide the required functionality of the component in a manner which drastically cuts down the level of waste material, lead time and costs. The environmental impact takes advantage since the total energy required to obtain the component is dramatically reduced, consequently cutting down CO_2 emissions.

With good process control, near-net shapes have mechanical properties approaching and sometimes exceeding conventional technologies as forging and casting.

The advantages of NSHIP method relative to conventional techniques are:

- components with better mechanical properties and dimensional accuracy with respect to cast components,
- reduction of machining costs and manufacturing lead time with respect to forged products.

NSHIP gives homogeneous and isotropic material, ensures very low slag inclusion level and also adds new degrees of freedom in shaping the products.

The proposal is to develop a new LPT casing obtained by NSHIP technique using Astroloy, a Nickel-based superalloy which behaves better than Waspaloy especially at high temperature. The aim is to use this technology to produce a demonstrator component in order to achieve a manufacturing readiness level 5 (MRL5) and test the component on the SAGE2 ground test demo to achieve a TRL6.

Mechanical properties of the casing produced in Astroloy by NSHIP shall be comparable or higher than the properties of the same casing in Waspaloy obtained by forging process.

The driving force in the substitution from conventional forging to NSHIP components rely on reduced waste material and manufacturing lead-time, design flexibility, improved quality and isotropic properties and an advantageous cost for the final component.

The proposal activity is planned through the following tasks:

Task 1: Management.

This task will provide the framework for effective management of the programme. It will establish the management team dedicated to the project, the reporting schedule and work package description.

With the progress of the project teleconferences and meetings will be planned in order to have a regular coordination of the activities.

Task 2: Setting up of the process and heat treatment with microstructural and chemical analysis.

All the aspects of powder processing which need to be developed in this programme shall be studied.

Preliminary studies on powders (dimensions and distributions) and process parameters (temperature and pressure) will be done in order to assess final mechanical properties. In this phase the mould design will be developed.

Heat treatment conditions have to be defined in order to optimize component quality and performance. On specimens obtained with the defined process parameters microstructural and chemical analysis will be done to assess the effect of heat treatment on the microstructure.

Task 3: Mechanical characterization.

Mechanical and thermal stability characterization shall be performed on specimens obtained from the cut-up of a shape representative of the final casing in the heat treated conditions as defined in task 2.

Metallurgical Laboratory and test facilities must be certified following the international certification standards (as required for aeronautical application, e.g. Nadcap certification).

The tests that shall be performed are:

- tensile tests at room temperature and at high temperature up to 820°C;
- fatigue tests, LCF performed at room temperature and at high temperature up to 760°C and HFC tests done at room temperature;
- creep tests and stress rupture tests performed at high temperature up to 820°C;
- fatigue crack growth tests.

Thermal stability characterization shall be performed to assess the effect of high temperature long term-exposure on microstructure and mechanical properties.

Specimens with as HIPped surfaces shall be produced and tested to verify the impact of surface roughness on fatigue behaviour.

An assessment and statistical evaluation of typical process defect will be carried out together with the evaluation of the impact of such defects on mechanical properties.

The Topic Manager will provide mechanical properties of forged Waspaloy in order to make a comparison with Astroloy properties.

Material specification for HIPped Astroloy and related powder shall be defined (e.g. chemical composition, microstructure, heat treatment, minimum mechanical properties).

A detailed test plan shall be agreed between the proposal and the applicant.

Task 4: Manufacturing of a small-scale demonstrator.

A modelling of thermal densification and rheological properties of the powders with simulation tools shall be used to simulate the HIP process.

The development of all aspects of work required for the production and assessment of demonstrator shall be defined in this phase in order to manufacture a small-scale demonstrator. The aim of this task is to assess dimensions and microstructural homogeneity of the casing with not destructive and destructive tests.

The maximum diameter of the casing is approximately 1300mm.

The task will investigate the possibility of dimensional changes of the mould and evaluate surface treatments, such as mechanical or chemical polishing.

For the evaluation of material properties and for the optimization of heat treatment the cut-up of this casing have to be included.

Non-destructive tests, like fluorescent inspection and X-ray or ultrasonic inspection, and destructive test will be carried out in order to detect bulk and surface defects, measure distortions after heat treatments and assess the microstructure homogeneity.

At the launch of the present project (M0) the topic manager will provide the 3D model of the final part.

At M6 of the present project the topic manager will provide the 2D drawing of the final part.

At M7 (target end of Tasks 3 and 4) a go/no-go gate is scheduled: Task 5 will be activated if T3 and T4 will respect target schedule and technological maturation.

Task 5: Manufacturing of the final casing for the demonstrator.

After a review of material properties, the component for demonstrator will be manufactured by applying the results of technology development and with respect to the 2D drawings provided by the TM as described in the Task 4.

Non-destructive tests of the final casing for the demonstrator will be carried out (fluorescent penetrant inspection and X-Ray or ultrasonic inspection).

Process specification shall be defined, including information on process control, parameters having an influence on final component material properties and how these parameters have to be monitored and controlled.

At the end of the activity MRL shall be assessed.

Task 6: Cost benefit analysis.

All environmental, cost and socio-economic data shall be collected in order to assess of costs, impacts and benefits of the introduction of NSHIP process for producing casing instead of forging process.

2. Special skills, certification or equipment expected from the applicant

Necessary Equipment:

Extensive and proven experience in design, validation and manufacturing of high technology aerospace products (in particular Pressure Turbine static sub-modules) is mandatory.

Availability of technologies at an high readiness level to minimize program risks is an asset.

The Applicant needs to demonstrate to be in the position to have access to facilities required to meet the Topic goals (e.g. plant to machine turbine casings with outer diameter up to 1300mm).

Experience in Supply Chain management is mandatory.

Experience in aerospace R&T and R&D programs is a benefit.

The activity will be managed with a Phase & Gate approach and management plan has to be provided. The Topic Manager will approve gates and authorize progress to subsequent phases.

Technical/program documentation, including planning, drawings, design reports, risk analysis, FMEA, test plan and test requirements, test results, test analysis reports must be made available to the Topic Manager.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Management report	Report describing the project management	T0+12 months
D2	Setting up of the process and heat treatment	Report describing process and heat treatment parameters, with the results of microstructural and chemical analysis	T0+4 months
D3	Mechanical characterization	Report describing the results of mechanical and thermal stability characterization and the comparison between NSHIPped Astroloy and forged Waspaloy	T0+7 months
D4	Manufacturing of first demo	Report describing the manufacturing of the first casing with the results of non-destructive and destructive tests.	T0+7 months
D5	Manufacturing of final demo	Report describing the manufacturing of the final demonstrator.	T0+10 months
D6	Cost benefit analysis	Report of costs and benefits of the introduction of NSHIP process	T0+12 months

Milestone	Title	Description (if applicable)	Due date
M1	Availability of casing	Availability of the first casing with the results of non-destructive and destructive tests for the MRL validation.	T0+7 months
M2	Availability of casing for demo	Availability of the final casing for the monstrator.	T0+10 months

4. Topic value (€)

900.000 €

[nine hundred thousand euro]

The proposed topic value is a maximum gross value for the proposed activity.

5. Remarks

The proposal of the applicant has to include maximal realizable values for every given requirement. A detailed work plan and time schedule is being expected. A profound financial plan must be attached as well. The applicant must fulfil the above mentioned requirements.

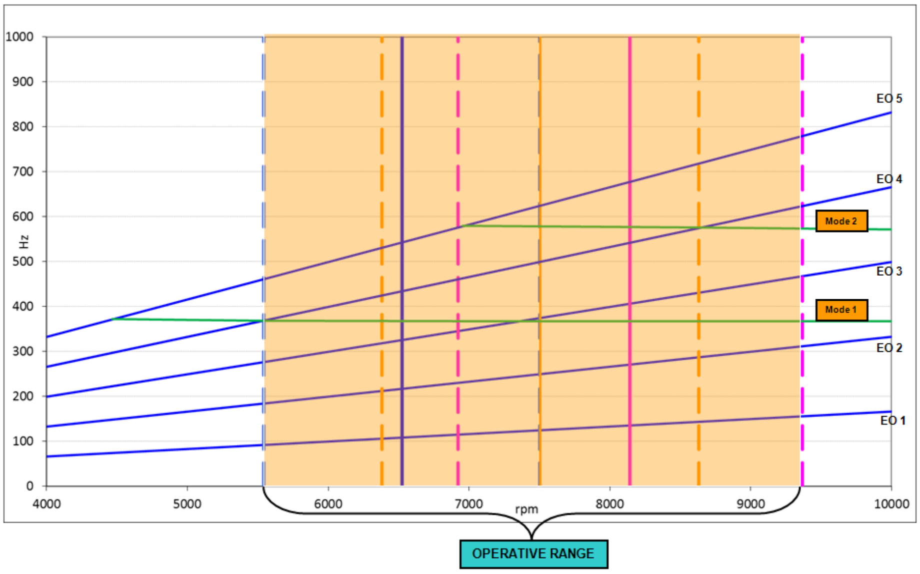
Topic Description

CfP topic number	Title		
JTI-CS-2013-02-SAGE-02-040	***Non-intrusive Turbine Blade measurements***	**Start date**	*T0*
		End date	*T0 +24*

1. Topic Description

Blade fatigue problems are critical aspects in High Speed Turbine. Due to the high rotational speed, the pull-load on the blades results in a high static stress and deflection (LFC). In addition, Low Engine Orders (rotor unbalancing and misalignments) become particularly stronger and with unusual high-frequencies for LPT (also airfoil modes can be excited). Within this scenario it is crucial to avoid an excessive blade static stress and any critical resonance in the operative range.

In order to validate the SAGE2 Turbine mechanical design it is necessary to measure the static and dynamic behavior of SAGE2 turbine bladed-disks. In particular, it is important to take advantage of the DEMO ground test to characterize the level of static deflection and dynamic response of the Turbine Blades. Unlikely, due to the DEMO layout and space limitations it will not be possible to mount a conventional rotating instrumentation (i.e. Strain Gauges) and hence non-contacting measurement techniques (i.e. tip-timing) are required for the mechanical validation.

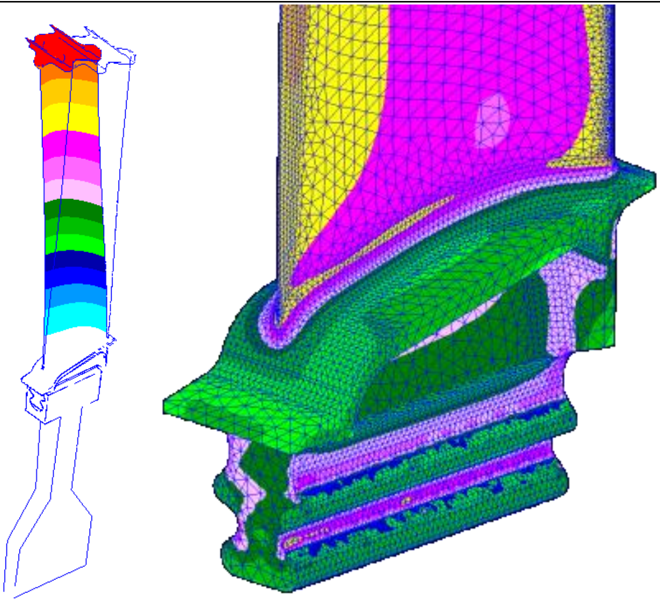


The objective of the proposal is to develop appropriate measurement techniques in order to characterized the blade static deflection and blade dynamic behaviour of the DEMO high speed turbine (tip-shroud interlocked configuration bladed-disks).

The proposed activity is planned through the following steps:

WP1 - INSTRUMENTATION SPECIFICATION (M0 – M2)

Instrumentation specification. Numerical simulation of the expected blade deflection. Numerical identification and simulation of potential blade resonances of interests.

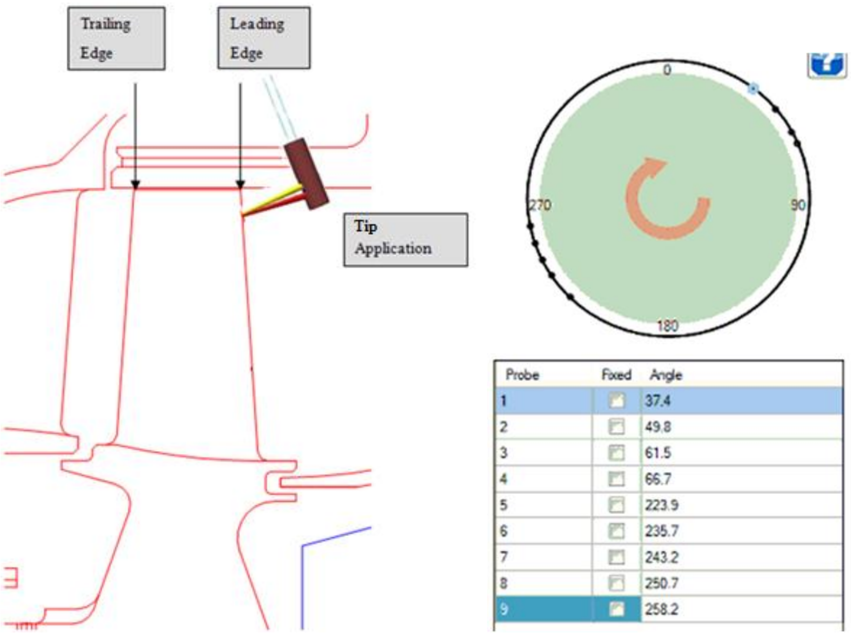


WP2 - INSTRUMENTATION DESIGN (M2 – M8)

Based on the specification output of the WP1 the overall instrumentation system (probe kind, number, targeting, positioning, …) has to be defined and adapted to the DEMO requirements and layout.

The Applicant must:

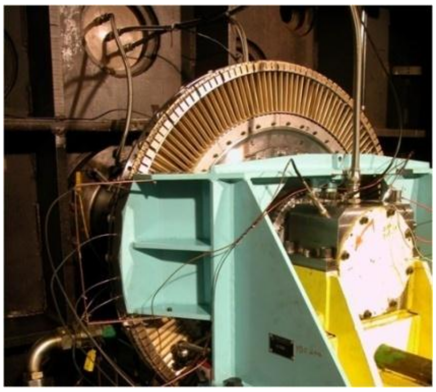
- provide instrumentation installation schemes
- support the final instrumentation drawing release (overall module design under Topic Manager Responsibility)



WP3 - INSTRUMENTATION VALIDATION (M3 – M9)

The instrumentation design must be validated by numerical analysis.

The applicant can also proposed an additional validation (if needed to substantiate the application of the Technology on proposed product) through experimental activities such as representative spintests on DEMO scaled geometry. These tests could be performed in a dedicated Rig; the Rig itself, and the potential required adaptation, will be part of the present Topic, and will be under the Applicant responsibility. The Topic Manager will support the Applicant in case of Rig unavailability; the previous scenario is the preferred. The scaled TA (SAGE 2 DEMO representative Geometry) will be provided by the Topic Manager. The Applicant must be responsible of the Instrumentation Validation test.



WP4 - INSTRUMENTATION INSTALLATION INTO SAGE 2 GROUND ENGINE DEMO (M12 – M18)

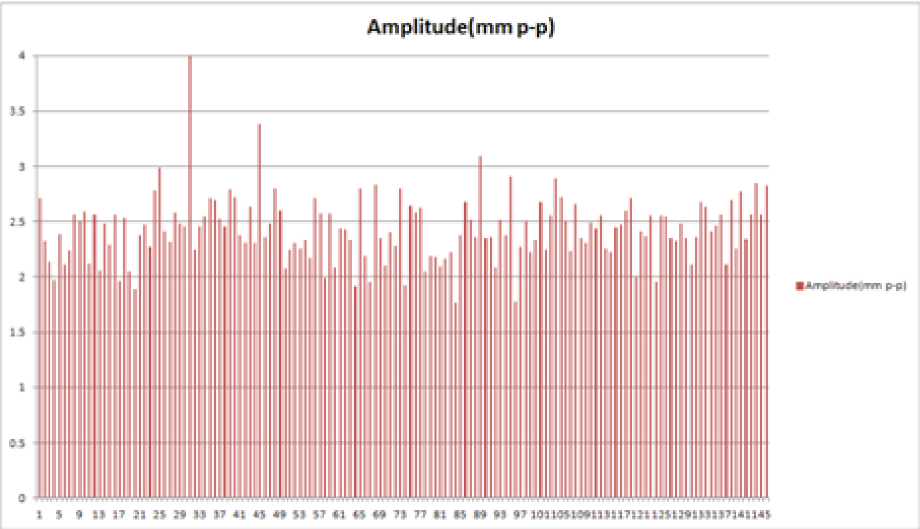
The measurement system designed in WP1-2 (and possibly validated and calibrated at WP3) will be installed in the SAGE 2 DEMO engine for the blade deflection and vibration measurement.

The Applicant must:

- provide the validated instrumentation and required assembly tools and cabling
- support the installation on the DEMO Engine

WP5 – TEST SUPPORT AND FINAL ASSESSMENT (M18 – M24)

The Applicant should support the SAGE 2 DEMO test campaign for the blades deflection and vibration measurement. A full mechanical characterization of the high speed bladed-disk will be available after the ground tests.



A final assessment of the deflection and vibration behaviors of the DEMO will be performed. Tools and design practice will be updated as a consequence.

2. Special skills, certification or equipment expected from the applicant

Necessary Equipment:

Extensive and proven experience in enhanced sensors (e.g non-contacting measurement techniques), for aerospace products (in particular Pressure Turbine sub-modules), design, validation and manufacturing is mandatory.

Proven experience in aircraft engine and sub-modules (Pressure Turbines) instrumentation (design, validation and manufacturing) is mandatory.

Availability of technologies at an high readiness level (TRL≥6) to minimize program risks is an asset in order to minimize the risk.

If technology substantiation will be needed, the Applicant should be in a position to have access to the test facilities required to meet the Topic goals.

Experience in Supply Chain management is mandatory.

Experience in aerospace R&T and R&D programs is a benefit. The activity will be managed with a Phase & Gate approach and management plan has to be provided. The Topic Manager will approve gates and authorize progress to subsequent phases.

Technical/program documentation, including planning, drawings, design reports, risk analysis, FMEA, test plan and test requirements, test results, test analysis reports must be made available to the Topic Manager

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1.1	DEMO Instrumentation Specification	Report on DEMO Instrumentation Specification	M2 (end of WP1)
D2.1	Instrumentation design/layout	Report on details instrumentation design & layout	M8 (end of WP2)
D3.1	Instrumentation validation	Report on instrumentation assessment and potential design improvements (input for WP2)	M9 (end of WP3)
D4.1	Instrumentation Installation on Ground DEMO Engine	Report on instrumentation installation on Ground DEMO Engine	M18 (end of WP5)
D5.1	DEMO Mechanical Assessment	Final Report on SAGE 2 DEMO test campaign	M24 (end of WP6)
Milestones	**Title**	**Description (if applicable)**	**Due date**
M4.1	Availability of validated instrumentation for DEMO Engine and assembly tools	Validated instrumentation and assembly tools available	M12
M4.2	Validated instrumentation assembled on DEMO Engine	Validated instrumentation assembled (DEMO Engine ready for testing)	M18

4. Topic value (€)

1.050.000 €

[one million fifty thousand euro]

The proposed topic value is a maximum gross value for the proposed activity.

5. Remarks

The proposal of the applicant has to include maximal realizable values for every given requirement. A detailed work plan and time schedule is being expected. A profound financial plan must be attached as well. The applicant must fulfil the above mentioned requirements.

Topic Description

CfP topic number	Title		
JTI-CS-2013-3-SAGE-03-024	**Electric Pump for Safety Critical Aero engine applications**	**Start date**	T0
		End date	T0+24

1. Topic Description

The SAGE3 project aims at development and demonstration of a large 3-shaft bypass engine Demonstrator. RTD activities are foreseen on developing electrically driven pumps to replace traditional mechanically driven variants in engine externals. The objective of the topic is to develop this technology and demonstrate to Technology Readiness Level (TRL)6.

Pumping applications can include fuel, oil and other fluidic substances depending on the engine application. For the purposes of exploring the viability of electric pumping solutions, the oil system is chosen as the candidate fluid for this demonstration.

It is likely that the preferred solution will be mounted within the core zone of a large gas turbine eninge, during the initial design it would be advantageous for the partner to consider how the unit could be designed to operate in various locations within the engine, e.g. Core or fancase mounted with the associated implications that vibration and temperature environment will have on cost and weight of the unit.

The Partner should read this topic thoroughly and when preparing a proposal take particular notice of section 5 of this document - Remarks

The Partner shall in particular perform the following tasks:

Task 1: Design and analysis of electrically driven oil pump and breather

The partner will work with the Topic Manager to agree a target specification against which to work. An outline of typical characteristics is included later in this section. Against this specification, the Partner will conduct the appropriate mechanical, electrical and electronic concept and detail design of both feed and scavenge elements of an oil pump and also an oil-air breather suitable for deployment in a safety critical application within a large civil engine environment.

The Partner is expected to recommend new and novel pump configurations and will preferably demonstrate how the pump, associated electric motor and motor drive will interface to an Electronic Engine Controller. Whilst initial investigations into this technology have considered the preferred solution to be a mechanically ganged multi-element gerotor based pumps driven through permanent magnet electrical motors, the partner will be expected to consider alternative solutions for each technology area. Strategies to ensure the correct synchronisation between individual pumping elements (e.g. between feed and scavenge in the oil application) shall also be addressed.

The Partner is expected to recommend new and novel breather configuration and will preferably demonstrate how the pump, associated electric motor and motor drive will interface to an Electronic Engine Controller. Strategies to reduce oil leakage and staining shall also be addressed.

The Partner will provide a detailed verification proposal for the new pump and breather. The solution shall be demonstrated to TRL6 (i.e. in an environment representative of an engine installation) and proposals shall include a technology validation plan to show how this requirement will be met. If it is expected that the SAGE Members will contribute to the delivery of this plan then this should be highlighted.

Any material testing or manufacturing trials required to validate the design choices shall be carried out and reported by the Partner to the Topic Manager.

Task 2: Electrically driven pump and breather manufacturing and assembly

The Partner will procure all materials and fittings and manufacture all material, test parts and components for rig testing necessary to support validation of the pump and breather and support design and manufacturing technology.

It is expected that demonstration of the electrically driven pump technology will necessitate its' integration into a representative system demonstration or engine test. If it is agreed between the Partner and Topic Manager that such testing is required as part of the technology validation plan then the Partner will also be required to provide a number of additional parts for this testing. Proposals should indicate how this will be supported and identify specific features requiring this level of validation.

It is expected that demonstration of the novel breather technology will necessitate its' integration into a representative system demonstration or engine test. If it is agreed between the Partner and Topic Manager that such testing is required as part of the technology validation plan then the Partner will also be required to provide a number of additional parts for this testing. Proposals should indicate how this will be supported and identify specific features requiring this level of validation.

Task 3: Electrically driven pump and breather validation support

The partner will conduct and report on all testing as necessary to ensure that the unit(s) meets the specification requirements as appropriate to demonstrate compliance to engine environment TRL6.

If it is agreed that system demonstration or engine testing is required then the Partner shall support that testing through the preparation, test and appraisal phases. During any test facility build it is envisaged that on-site support will be required but on-call support would be acceptable during any testing that might be agreed. The Partner will supply all instrumentation necessary to validate the pump, motor and drive and components will be supplied already instrumented whenever possible.

Task 4: Typical Electric oil pump operating environment

Temperature

The unit shall be capable of operation in a typical ambient environment of -55ºC to 200ºC.

Vibration

Consideration shall be made of how the unit might operate within the vibration spectrum of a typical large aero engine.

Compatible Fluids

The pump will be designed to operate on a range of engine oils, demonstrated to have acceptable characteristics under engine operating conditions. The pump shall be capable of using and compatible with oil conforming to SAE AS5780 HPC and also be compatible with all oil brands qualified to MIL PRF-23699 F.

Oil Pumping

The Oil Pump assembly provides a flow of oil to the Engine components for cooling and lubrication with typical flow rates, temperatures and pressures as shown in the following table:

Typical Feed Element Parameters		MHD MTO Nominal Requirement	ISA MTO Nominal Requirement
Inlet conditions			
Inlet temperature	ºC	172	152
Inlet Pressure	psia	25	26
Flows			
Pump flow at Pump inlet temperature	IGPH	1864	1801
Pump Discharge pressure (max)	psia	332	360

MHD – Maximum Hot Day; ISA – International Standard Atmosphere; MTO – Maximum Take Off; IGPH – Imperial Gallons per Hour

Sumps to be scavenged

The Oil Pump assembly provides a means of scavenging oil mixed with entrained air from multiple locations with typical characteristics as shown in the following table:

Typical Scavenge Element Parameters

Parameter	Unit	Chamber	MHD MTO Nominal Requirement	ISA MTO Nominal Requirement
Inlet temperature	ºC	Chamber #1	154	136
		Chamber #2	230	222
		Chamber #3	182	163
		Chamber #4	182	165
		Chamber #5	148	127
		Chamber #6	142	110
		Chamber #7	124	96
		Chamber #8	154	132
		Chamber #9	205	193
Nominal Scavenge Flow	IGPH	Chamber #1	414	408
		Chamber #2	529	494
		Chamber #3	145	135
		Chamber #4	112	103
		Chamber #5	73	70
		Chamber #6	140	140
		Chamber #7	92	92
		Chamber #8	110	110
		Chamber #9	443	506
Nominal Volumetric Air/Oil Ratio		Chamber #1	3	3
		Chamber #2	4	4
		Chamber #3	4	4
		Chamber #4	4	4
		Chamber #5	7.5	7.5
		Chamber #6	2.5	2.5
		Chamber #7	2.5	2.5
		Chamber #8	3	3
		Chamber #9	1.8	1.8
Nominal Total Volumetric Flow	IGPH	Chamber #1	1654	1631
		Chamber #2	2646	2470
		Chamber #3	723	674
		Chamber #4	559	515
		Chamber #5	621	592
		Chamber #6	490	490
		Chamber #7	322	322
		Chamber #8	440	440
		Chamber #9	1241	1416
Pump Inlet Pressure	psia	Chamber #1	21	21
		Chamber #2	127	152
		Chamber #3	127	152
		Chamber #4	127	152
		Chamber #5	48	56
		Chamber #6	20	22
		Chamber #7	20	22
		Chamber #8	20	22
		Chamber #9	20	22
Pump Discharge Pressure	psia	Chamber #1	48	50
		Chamber #2	48	50
		Chamber #3	48	50
		Chamber #4	48	50
		Chamber #5	48	50
		Chamber #6	48	50
		Chamber #7	48	50
		Chamber #8	48	50
		Chamber #9	48	50

2. Special skills, certification or equipment expected from the applicant

Extensive experience in the detail design, development, manufacture and validation of electric drives and pumping technologies. In-service operation of aerospace applications would be advantageous. Experience of suitable quality control systems is essential.

Successful experience, with demonstrable benefits, of application of innovative manufacturing and material technologies to reduce weight and cost of parts is an asset. Availability of technologies at a high technology readiness level to minimise programme risks is an asset.

Experience in R&T and R&D programs. Experience of aerospace related research programs would be an advantage.

The Partner needs to be in the position to have access to the manufacturing facilities suitable for making an agreed set of equipment suitable for system integration or engine test if required.

The Partner needs to have access to rig test facilities for vibration & thermal endurance testing.

The activity will be managed with a Phase & Gate approach and management plan has to be provided. The Topic Manager will approve gates and authorise progress to subsequent phases.

Technical/programme documentation, including planning, drawings, manufacturing and inspection reports, must be made available to the Topic Manager.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1.1	Electric oil pump launch and concept review	Participate in launch review for project	T0+1
D1.2	Electric oil pump and breather technical specifications	Agreed specification against which to continue project	T0+2
D2.1	Electric oil pump and breather Prelim Design Reviews		T0+4
D2.2	Electric oil pump and breather Critical Design Reviews		T0+6
D2.3	Initial Electric Oil Pump Test Readiness Review		T0+10
D3.1	Launch manufacture of tech demo hardware for validation testing		T0+8
D3.2	Deliver validation hardware		T0+12
D4.1	Complete initial unit acceptance testing		T0+12
D4.2	Complete Validation testing and initial assessment		T0+18
D4.3	Release final test report and project closure documentation		T0+24

4. Topic value (€)

1,750,000€
[One million, Seven Hundred and Fifty Thousand euro]

This topic value is a maximum gross value for the work package. Awards between 50% and 75% of this value may be made by the Clean Sky Joint Undertaking. Note that VAT is not an eligible cost in the context of this RTD activity.

5. Remarks

Content of the proposal (including these items will significantly enhance the proposal)
a) A clear and precise budget breakdown should be provided, outlining spend in all areas of the programme (human resource, outsourcing, materials, capital spend, etc.)
b) A detailed Risk Assessment – key programme, technology, material, manufacturing and budget risks.
c) Detailed design and make plan with decision gates and contingency loops. The plan must include a clear material and feature selection process.
d) The proposal must include details of material supplier agreements. Lead times for material delivery, quantities, costs, contingencies, etc. should be indicated.
e) The proposal should include ROM estimates for unit cost and weight.
f) Verification of successful manufacture. Requirement to demonstrate in proposal how the Partner would ensure a unit is acceptable for usage within the engine conditions listed.
g) The partner should identify key certification drivers from appropriate regulatory bodies (e.g. EASA CS-E) and show how compliance with those requirements will be demonstrated
h) Partner to suggest any parts of the manufacture process that could be improved / automated for main line unit delivery.
i) Partner to suggest how the technology under development could be applied to other market sector, and also how existing technology developments from other market sectors could be usefully adapted to meet the specific needs of this opportunity.

Topic Description

CfP topic number	Title		
JTI-CS-2013-04-SAGE-06-008	Instrumentation Capability for Accelerated Lean Burn development	**Start date**	T0
		End date	T0 + 20 months

1. Topic Description

Main goals

The SAGE6 Demonstration Project aims to develop and mature a lean burn combustion system suitable to civil aeropace up to TRL6. This will eventually be done via a demonstrator engine project involving ground level and flight tests of a representative lean burn system in a realistic environment.

Feasibility as well as maturity of proposed lean burn combustor designs solutions depend on their ability to work for a long time at the challenging operating conditions that are typical of modern civil aero engines. On the one hand, the trend towards higher cycle efficiency implies more demanding core temperatures and pressures, which make combustor durability a particularly challenging task. The lean burn combustion system has to satisfy many inter-related requirements including NOx, UHC, CO, soot emissions, low noise/thermo-acoustic instabilities, stable operation/weak extinction, low cooling budget, minimum pressure loss, low cost, low weight and integration with the turbine, compressor and control systems. It is essential to deliver on all these requirements in a competitive, reliable, air-worthy package. This can only be done using state of the art experimental and computational tools.

This project aims to develop instrumentation for experimental methods to provide more detailed, representative design data from areas previously inaccessible and to provide essential detailed boundary conditions to validate computational methods. Importantly, this will also enable the combustion engineer to design future combustion systems with authoritative data on the performance of the system and interpret results knowledgeably to accelerate the development of new technology.

This project will specifically deliver:

- A combustion temperature sensing technology applicable for engine control.
- A temperature or stoichiometry diagnostic for intermediate pressure and high pressure combustion testing.
- An imaging diagnostic for qualitatively imaging fuel stoichiometry with good spatial and temporal resolution in optical combustion experiments.
- A multi-channel, fast emissions measurement device for full annular combustion rig testing.
- A multi-channel, particulate matter measurement device for full annular combustion rig testing.

<u>Description of Work:</u>

<u>Task 1: Management</u>

Organisation:

– The partners shall nominate a team dedicated to the project and should inform the consortium programme manager about the name/names of this key staff.

Time Schedule & Work Package Description:

– The partners will work to the agreed time-schedule & work-package description.

– Both, the time-schedule and the work-package description laid out in this Call shall be further detailed as required and agreed at the beginning of the project.

Progress Reporting & Reviews:

– Three progress reports will be written over the duration of the programme. For all work packages, technical achievements, time schedule, potential risks and proposal for risk mitigation will be summarised.

– Regular coordination meetings shall be conducted via telecom where appropriate.

– The partners shall support reporting and agreed review meetings with reasonable visibility on its activities and an adequate level of information.

– Quarterly face to face review meetings will be held to discuss progress.

Task 2: Development temperature sensing technology for engine control and health monitoring

Optical pyrometry has been used in a number of military and civil gas turbine engines as a method of engine health monitoring and control for a substantial number of years. The technique is reliable but not without its problems and false readings. The pyrometers used in these applications look not at the flame itself but at metal components in the hot end of the engine such as turbine nozzle guide vanes (NGV's). In looking at the metal they have very limited field of view, almost point measurements on what can be a very large surface area. Therefore, they cannot detect problems arising outside of the field of view. In the past it was deemed acceptable that this limited field of view was acceptable, for a gross system level indication when coupled with knowledge of the operation of the style of combustion systems, namely rich quench lean (RQL) where there are well defined relationship between power setting and combustion chamber outlet temperature and hence point measurement on a metal surface. With the ever increasing pressure with respect to emissions issuing from the gas turbine and the continuous trend for reduction of gas species such as the oxides of nitrogen (NOx), new more complex combustion technologies are being applied. Here, these technologies rely on Lean burn staged combustion. The relationship between the combustor exit temperature and the power levels do not change at a global level for the combustion technology, this is cycle dependant, however the flame temperature pattern and shape will be modified when using lean burn staged combustion technology.

In order to monitor and detect abnormal flame behaviour within these systems will require a different way of sensing the changes to the flame. The optical pyrometers mentioned above will be of no use, the other way of identifying changes to the engines conditions is via turbine gas temperature's (TGT), either between turbines or at the turbine exit. The TGT is measured by a sparse array of thermocouples which may or may not be ganged together to give one reading of gas temperature in the engine. Due to the nature of the swirl within the turbines and the sparse nature of the measurements it is often difficult to identify problems within the RQL combustors, such as a blocked burner, the problem is magnified in lean burn due to internal burner fuel scheduling and intra burner fuel schedules. Identification of mal-scheduling or even scheduling valve failure becomes even more arduous.

A method of measuring the combustor exit temperature is required that can gauge the temperature circumferentially and radially close to the combustor exit. Knowledge of these temperature patterns will be used to compare against the expected temperature patterns at a given demanded power setting and the demanded fuel schedule to different flame zones in the combustor. The temperature measurement must be that of the gas and not be effected in any way by radiation from the surrounding combustion and turbine hardware. Occasionally, there may well be carbon shedding or soot particles which radiate, the measurements should not be influenced by these events. Ultimately, these combustor temperatures will be used for fault finding and engine health monitoring.

The temperature measurements must be accurate and repeatable, the final instrument or instruments must be cheap, light and robust and be able to live at compressor exit temperatures and pressures up to circa 950K and 60 bar. The measurement method should be able to operate without the introduction of seeding particulates or tracer gases. The final instruments must meet stringent reliability criteria. That being said the instruments and techniques developed as part of this work can be prototype and proof of concept, with the ability to be further developed to meet the requirements stated above, for cost, weight and reliability.

It is envisaged the technique and instrument will be initially demonstrated on an intermediate pressure combustion facility, followed by demonstration on a high pressure combustion facility. The high pressure combustion facility will have extremely limited access to get the instrument/instruments in and the signals in and out.

Task 3: Development of a temperature or flame stoichiometry diagnostic for combustion low pressure and high pressure rig testing

The prime characteristic of any combustion system is the population of stoichiometry in combustor. This stoichiometry population defines the population of temperatures in flame and as such here can be used as substitutable parameter. This population is responsible for the entire combustion system performance such as emissions, soot, thermo-acoustics, weak extinction, altitude relight and cooling and hence is a key parameter to measure. To date temperature measurements are either made using intrusive methods (eg. thermocouples), sampling (temperature reverse calculated from gas species concentrations) or optical diagnostics. Stoichiometry measurements are made via probe sampling and conventional gas analysers or globally via spectroscopy. The currently available optical diagnostics for temperature/stoichiometry (eg. CARS) are currently impractical for realistic, high pressure testing due to their complexity or lack of reliability in sooty, liquid fuelled flames. A reliable measurement method is required to characterise the distribution of burnt mixture stoichiometry or flame temperatures for use in high pressure combustion experiments. The measurement method shall be able to operate without the introduction of seeding particulates or tracer gases. The measurement method shall endeavour to deliver the best combination of spatial (pointwise/ line of sight/ planar) and temporal resolution (steady state / transient enough to freeze the flow field).

This capability needs to be able to interface experiment in:

High Pressure Full Annular testing –imaging though exhaust or endoscopic

Intermediate Pressure sector/flame tube testing –imaging though transparent combustor walls.

Task 4: Development of a fast, imaging diagnostic for fuel, flame and stoichiometry imaging in low pressure combustion rig testing.

The Task 3 above will provide accurate data on combustion temperatures or stoichiometry in devices either using a pointwise, line of sight or planar measurement method which is preferably time resolved. This task focuses on simultaneously gathering data on the dynamics of the unburnt fuel and the flame stoichiometry using a spatially resolved, fast imaging diagnostic that characterises large parts of the combustor volume.

A technique is required to image the combustor flame in optical, intermediate pressure combustion rigs. This shall be fast to capture the flame dynamics. The technique shall seek to optimise the best combination of fast response with accuracy of measurement and spatial resolution. For example, a cruder spatial resolution (eg. binned image) would be an acceptable compromise to provide fast, representative data on stoichiometry. A means of tracking the fuel location simultaneously with the flame is required to observe flame dynamics.

A calibration trial is also required to measure the accuracy of using high speed colour video data to characterise the stoichiometry of a kerosene flame. A practical study on the feasibility of exploiting these techniques in high pressure engines using endoscopy is required for future exploitation. It is envisaged that the set up may also enable the provision of 3D flow fields using particle tracking velocimetry and would be an advantage to the project. Seeding shall be avoided for this technique.

Task 5: Development a multi-channel, fast emissions measurement instrument for full annular combustion testing

The existing UK and German full annular combustion test facilities rely on conventional, slow gas analysis technology to measure emissions and provide a limited return on the investment of a high pressure rig test. These facilities need upgrading to acquire spatial information on the species concentrations at the combustor exit. To enable more measurements to be made in an allotted test, a faster method of measuring species is required entailing a 1 minute measurement of the complete annulus.

A fast, multi-channel species measurement capability is required for interfacing with high pressure full annular rig testing. This needs to measure CO, CO_2, NO, NO_2 and unburnt hydrocarbons or an indicator thereof in the presence of H_2O. The instrument shall efficiently measure twenty channels simultaneously at 10Hz in a cost effective and reliable arrangement. The minimum flow rate available down each sample line is 35 l/min.

The number channels or sample rate can be altered if a more cost effective solution demands it.

The gas species range requirements are:

		CO2	CO	HC indicator	NOx	NO	H2O
		%	ppm	ppm	ppm	ppm	%
ideally	**min**	0.5	1	0.1	1	1	0.5
	max	8	5000	1000	1000	1000	10
reduced cost effective solution if required	**min**	1	20	0.5	15	10	1
	max	8	1500	200	750	750	10

Task 6: Development a multi-channel, fast soot measurement instrument for full annular combustion testing

The same facility and rationale for the Task 5 on emissions measurement needs an equivalent capability for soot or smoke emissions.

A fast, multi-channel particulate matter measurement capability is required for interfacing with high pressure full annular rig testing. This needs to measure the mass and number concentration or an indicator thereof of non-volatile particulate matter. The instrument shall efficiently measure 20 channels simultaneously at 10Hz in a cost effective and reliable arrangement. The flow rate available down each sample line is 35 l/min.

The soot range requirements are:

		Mass	Number
		µg/m3	#/cm3
ideally	**min**	1	1.00E+03
	max	20000	1.00E+08
reduced cost effective solution if required	**min**	5	1.00E+05
	max	10000	1.00E+08

2. Special skills, certification or equipment expected from the applicant

- Experience in experimental combustion testing
- Experience in combustion instrumentation for:
  - Fast emissions methods
  - Fast soot measurement and particulate matter science
  - Fast gas sampling and handling
  - Fast imaging of combustion dynamics and data processing
  - Optical methods for non-intrusive combustion experimentation and knowledge of spectroscopy

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Management report	2 reports will be written to summarise the project	T0+12 months, T0+20 months.

		management of the programme, including deliverables, level of spend and dissemination	
D2	Report and demonstration of non-intrusive temperature sensing technology.		T0 +20 months
D3	Report and demonstration of temperature or stoichiometry diagnostic in optical combustion rig.		T0 +20 months
D4	Report and demonstration of combustion dynamic imaging in optical combustion rig.		T0 +12 months
D5a	Presentation of concepts and down selection of technology for fast emissions measurement.		T0 +3 months
D5b	Report and demonstration of fast, multi-channel gaseous emissions device.		T0 +20 months
D6a	Presentation of concepts and down selection of technology for soot measurement.		T0 +3 months
D6b	Report and demonstration of fast, multi-channel particulate matter measurement device.		T0 +20 months

4. Topic value (€)

€ 2,150,000
[two millions one hundred fifty thousand euro]

Clean Sky Joint Undertaking
SP1-JTI-CS-2013-03-SAGE-06-009

Topic Description

CfP topic number	Title		
JTI-CS-2014-01-SAGE-06-009	Advanced methods for prediction of lean burn combustor unsteady phenomena	**Start date**	T0
		End date	T0 + 18 months

1. Topic Description

Main goals

The SAGE6 Demonstration Project aims to develop and mature a lean burn combustion system suitable for civil aeropace up to TRL6. This will eventually be done via a demonstrator engine project involving ground level and flight tests of a representative lean burn system in a realistic environment.

Lean Direct Injection designs have shown that lean burn can give low NOx emissions in aero-engines. However, adoption of lean mixtures leads to an increased sensitivity to unsteady combustion phenomena. To some degree, design of production-worthy lean burn combustion systems depends on the ability to sort out such unsteady behaviours during the development programme.

Burning at leaner air to fuel ratios increases susceptibility to thermoacoustic instabilities, which are fundamentally due to coupling between combustion system's acoustics and flame's unsteady heat release. Designing out these instabilities, often referred to as rumble, can be a very challenging task. In particular, the lack of accurate and reliable tools to predict the occurrence of rumble means that thermoacoustic issues are often encountered when the combustion system being designed has already reached full annular testing, i.e. TRL5. In practice, this is an expensive and inefficient process, which could be significantly improved if downselection of solutions characterised by acceptable levels of rumble could be achieved earlier in the design process.

Moreover, flame stability and in particular weak extinction becomes more of a challenge as a result of adoption of LDI concepts. While it is accepted that unsteadiness and turbulence-chemistry interactions play an important role, current understanding of the physics and chemistry underlying this phenomenon is limited. As a result, geometry-specific correlations have been developed by engine manufacturers, which have limited applicability to new LDI designs. Proper prediction of lean blow off has not been possible up till now. Availability of a validated method for true prediction of blow off would significantly benefit the lean burn development process, effectively enabling exploring a larger portion of the design space.

Improving accuracy and reliability of methods for prediction of thermoacoustics is usually difficult because rumble can be due to a relatively large number of potential causes. An approach is proposed here whereby a number of different issues will be investigated in detail with a view to embedding all the knowledge generated by the research in a single low order tool to be used to drive lean burn combustion system designs towards minimum rumble.

The damping characteristics of impingement-effusion tiles will be explored both experimentally and numerically with the objective to generating low order modelling capability to support the system design. Eventually, modelling improvements will be investigated to account for proper definition of compressor exit acoustic boundary conditions.

A fundamental building block for the prediction of thermoacoustics is the flame transfer function. This can be described as the ratio of unsteady heat release to unsteady velocity and can be derived either experimentally or numerically. A range of different techniques have been used in the past to derive the flame response in experiments and CFD. The work here proposed aims to investigate the impact of the type of forcing usually relied on rigs on the measured flame response. Single sector, multi sector and full annular rig tests of a simple but representative combustor/injector configurations wll be carried out and offer the benchmarking for the predictive techniques to be validated against. The outcome of the research will be an improved understanding of the flame-to-flame thermoacoustic interaction effects together with a validated set of low order and CFD tools for the prediction of thermoacoustic instabilities.

In order to improve understanding and predictive capability of lean blow off phenomena, the approach proposed here is to build upon recent development of advanced combustion models for both premixed and non-premixed combustion regimes close to extinction. In particular, the development is expected to be reliant on swirling flame experiments resembling gas turbine burning patterns closely. The outcome shall be a validated combustion CFD method for prediction of blow off. This will be embedded into the unstructured, pressure-based, cell centred in-house combustion CFD code PRECISE, which will be made available by the ITD under appropriate conditions. Hands-on experience with this code would be an advantage.

Unsteady combustion effects can have a dramatic impact on technology demonstrators. In particular, thermoacoustic instabilities (e.g. rumble) can significantly limit the operating envelop of the demonstrator engines. A challenging aspect of thermoacoustic instabilities is represented by the fact that they can be due to a wide range of causes, some of which may be active only when the combustor is operating in engine. The programme of work proposed here shall deliver improved computational tools that, even if at development stage, will help with the understanding and ultimately the resolution of combustor instabilities as they will emerge from the testing of the lean burn demonstrator programme (e.g. from sea level testing and the flying test bed).

Task 1: Management

Organisation:

– The partners shall nominate a team dedicated to the project and should inform the consortium programme manager about the name/names of this key staff.

Time Schedule & Workpackage Description:

– The partners will work to the agreed time-schedule & work-package description.

– Both, the time-schedule and the work-package description laid out in this Call shall be further detailed as required and agreed at the beginning of the project.

Progress Reporting & Reviews:

– Three progress reports will be written over the duration of the programme. For all work packages technical achievements, time schedule, potential risks and proposal for risk mitigation will be summarised.

– Regular coordination meetings shall be conducted via telecom where appropriate.

– The partners shall support reporting and agreed review meetings with reasonable visibility on its activities and an adequate level of information.

– Quarterly face to face review meetings will be held to discuss progress.

Task 2: Validation of low order acoustics modelling

Testing will be carried out to measure damping characteristics of advanced effusion cooling systems. The sensitivity of the damping characteristics to different types of acoustic forcing will be investigated. Such measurements will then be used to validate a CFD-based approach to calculate resistance and reactance of chosen impingement-effusion (IE) cooling configurations. This validation effort will deliver a CFD-based tool for prediction of damping characteristics. In the end these characteristics will be embedded in the low order model. As a result, trade off studies between cooling and damping effectiveness will become possible.

The impact of the compressor exit acoustic boundary conditions on the combustion system thermoacoustics will be investigated. Whereas a simple modelling approach is based on assuming the combustion system inlet to be choked, the high pressure compressor will have its own impedance. To start with, sensitivity studies will be made to quantify the impact of different inlet boundary conditions to the prediction of combustor instabilities in the low order model. Next, the inlet impedance will be derived using an acoustic low order model of the high pressure compressor. This impedance inlet boundary condition will be implemented in the low order model of the combustor.

Task 3: Validation of methods for prediction of thermo-acoustics of full annular combustion systems

A full annular reacting rig will be used to investigate the thermoacoustic response of a full annular combustor to forcing. The forcing will be devised to induce circumferential and axial modes respectively in the system. A comprehensive suite of measurements will be used, including dynamic pressures and OH* chemiluminescence. The measurement dataset will be relied on to derive flame transfer functions. The flame transfer function derived from the full annular rig will be compared against the one derived from single and multisector rigs. The multi-sector and full annular rig measurements will be taken on configurations characterised by different injector spacing in order to investigate flame-to-flame interactions. Single sector, multi-sector and full annular configurations will be simulated using CFD aimed to derive flame transfer functions through forced simulations. The measured flame transfer functions will allow validating the CFD approach. Linear and non-linear effects will be investigated experimentally and simulated using the low order modelling method through a flame transfer function and flame describing function approach respectively. In such a model, the flame transfer function will be either approximated using a G-equation approach or directly derived from CFD.

Task 4: Development of validated methods for prediction of lean blow off

An atmospheric gaseous and liquid-fuel burner with co-flowing air streams with co- and counter-swirl and stabilisation is expected to be developed to provide validation data. Fast diagnostics (OH*,OH-PLIF measurements up to 10 kHz) will be used to provide information on the flame structure and emissions as the lean extinction condition is approached.

The measurement data will then be used to validate further development of CFD methods for prediction of extinction for both non-premixed and premixed combustion regimes. A Conditional Moment Closure (CMC) modelling approach is expected to be adopted and improved upon for non-premixed combustion. As far as the premixed combustion regime is concerned, a Scalar Dissipation Rate (SDR) model is expected to be adopted. While an LES approach is believed to be required, the possibility of using RANS is not ruled out. All modelling improvements should be embedded into the in-house combustion CFD code, which is pressure-based, cell centred.

2. Special skills, certification or equipment expected from the applicant

- Experience in experimental techniques for measuring flame transfer function
- Single and multi-sector forced rigs with measurements of heat release available
- Full annular rig enabling measurement of heat release available
- Low order combustor thermoacoustic network modelling capability (both linear and non-linear)
- Low order turbomachinery acoustic network modelling capability
- Experience in experimental and numerical techniques to derive acoustic damping
- Experience in experimental methods for measurement of extinction for premixed and non-premixed combustion regimes
- Experience in modelling (CMC and SDR based) for characterisation of lean blow off
- Hands-on experience in development and use of PRECISE

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Management report	report will be written to summarise the project management of the programme, including deliverables, level of spend and dissemination	T0 + 18 months
D2	Validated model for prediction of IE tile damping	Report describing the validated CFD-based approach for prediction of reactant and	T0 + 18 months

		resistance for impingement-effusion tiles	
D3	Improved low order model	Report describing the network modelling improvements based on improved compressor boundary, non-linear effects and G-equation	T0 + 14 months
D4	Full annular facility test results	Report describing the results of the forced experiments on the full annular facility including comparison with single and multi-sector testing	T0 + 18 months
D5	Validated CFD methods for prediction of full annular combustion rig instabilities	Report describing the validation of the CFD method for prediction of rumble	T0 + 18 months
D6	Swirl combustor rig test results	Report describing the results of the test on the swirling flame	T0 + 14 months
D7	Improved CFD methods for prediction of lean blow off of premixed and non-premixed flame	Report describing the improved SDR and CMC modelling methods, including validation	T0 + 18 months

4. Topic value (€)

€ 950,000
[nine hundred fifty thousand euro]

Topic Description

CfP topic number	Title		
JTI-CS-2014-01-SAGE-06-010	Smart methods for lean burn injector design	**Start date**	T0
		End date	T0 + 18 months

1. Topic Description

Main goals

The SAGE6 Demonstration Project aims to develop and mature a lean burn combustion system suitable for civil aerospace up to TRL6. This will eventually be done via a demonstrator engine project involving ground level and flight tests of a representative lean burn system in a realistic environment.

Low NOx emissions have been shown to be achievable through adoption of Lean Direct Injection (LDI) designs. In this concept, most of the design ingenuity resides in the injector: stoichiometry, mixing, unsteadiness and in general aerodynamics are mainly dictated by the fuel injector in a lean burn system. As a result, lean burn combustor geometries tend to be simple, whereas lean burn injectors end up being geometrically complex. Moreover, it is well known that small changes in the injector geometry can have a large impact on its performance parameters. Figure 1 gives an idea of the typical level of complexity of a lean burn injector.

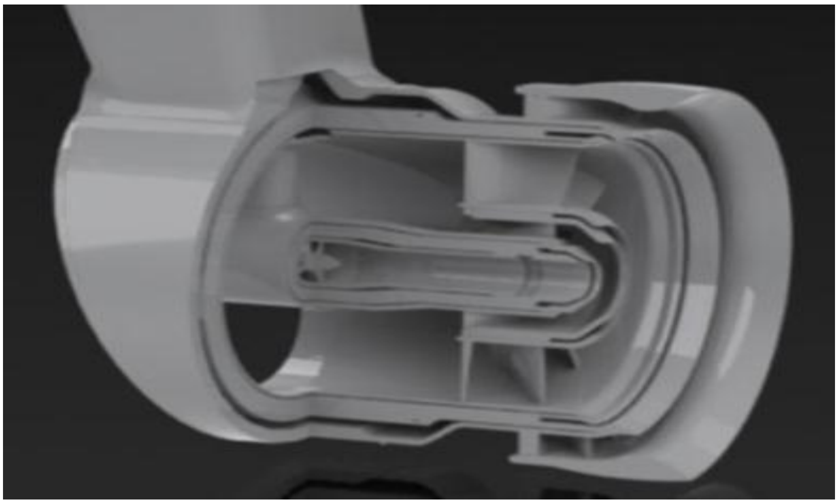


Fig. 1: typical layout of a lean burn injector

Piloted injectors have been demonstrated in previous EU-funded research programmes to have the potential to meet stability and current and future emissions requirements. Furthermore, simulation tools have been developed in the past to support various steps of the fuel injector design process. However, there is a need to integrate these fuel injector specific predictive tools to speed up the design and analysis process. Automation of the tools allows for greater exploration of the design space, and the implementation of design robustness studies, early in the development programme. At a later stage, numerous interfaces are fixed so flexibility is severely limited. An absence of this extensive design exploration work leads to higher costs and compromised performance due to the constraints on the injector design by surrounding interfaces.

A programme of work is here proposed to develop an integrated fuel injector design system based on existing analysis tools. Emphasis will be placed on a flexible definition of the injector parameters, which will allow moving from one topology to another with minimum effort. Such injector parametric model will be driven by a preliminary design tool defining the bulk properties based on requirements dictated by the combustion system design. Knowledge will be embedded in the parametric model to enable automatic generation of analysis models to be used to support the design. The master geometry model will spawn off geometries ready to be used for the subsequent analysis steps without need for further adjustments. The geometry modelling approach will be based on objects and/or standard features.

The integrated modelling system proposed shall allow speeding up any fuel injector design iteration required and in particular it will lead to optimal utilisation of the data produced as part of the lean burn demonstrator programme. In turn, this will deliver an improved understanding of the implications of using lean burn in a large by pass ratio engine through better characterisation of aerodynamics, fuel dynamics and thermals of the injector, which will ultimately help increase the maturity of the technology. Some of the issues associated with usage of lean burn injectors will crop up during sea level and Flying Test Bed (FTB) testing. Availability of the proposed toolset, even if at development stage, shall enable tackling the problems promptly and finding suitable solutions/mitigations.

To start with, an airflow network model will be generated to estimate the pressure drop and airflow split. Next, a detailed CFD model will be automatically built to derive the injector effective area together with details of the aerodynamics. The design system will be able to build a mesh using a feature recognition method in order to remove the need to tag surfaces manually. This will make it easier to apply the meshing best practices to different injector topologies. In a similar fashion, the master model will generate a geometry suitable for simulation of fluid dynamics of the fuel passages. The corresponding CFD model will be generated automatically using a feature-recognition approach to apply the boundary conditions. Such a model will support design of the fuel passages.

Whereas the first pass aerodynamic analysis will be performed assuming the injector to be operating in an idealised environment (e.g. plenum-fed injector in a box), in the subsequent step the injector aerodynamics will be simulated in a realistic combustor geometry. This will directly account for air inlet flow field effects as well as the impact of the downstream flame tube on the injector aerodynamic performance. An important requirement is the ability to embed the fuel injector model seamlessly into an existing combustion system design tool, which is based on an object oriented approach to geometry modelling and feature-identification functionalities for automatic surface tagging.

A further step will be the ability to create a thermal model of the entire fuel injector automatically. Internal and external thermal boundary conditions will be derived from the previous simulations to enable running a conjugate heat transfer calculation. This will also enable calculation of fuel temperatures, which together with residence times will provide some indication of the propensity of the proposed fuel gallery design to coking.

Availability of this integrated set of capabilities will pave the way for automatic multidisciplinary optimisation of the fuel injector. It is expected that at the end of the design system development, a demonstration will be provided of the ability to run such multidisciplinary optimisations.

An important requirement is the ease of modification of the system for it to cope with different injector topologies. Although the system will be developed for lean burn airblast injectors to start with, sufficient flexibility will have to be built in to allow modelling other types of injectors (e.g. single fuel system, jets in crossflow, etc). In order to minimise rework in the generation of scripts, an intelligent geometry-centric approach, wherein geometric features are identified automatically by the software based on a topological rule base, will be adopted for the design system. This will allow linking analysis model generation practices with geometric features.

The system will be designed with a view to integrating mechanical and cost analyses into the system in the future.

The software tools expected to be used as part of this programme and detailed later in this document will be either COTS or proprietary codes that will be provided by the ITD under appropriate usage licencing. Hands-on experience with this toolset would be an advantage.

Task 1: Management

Organisation:

– The partners shall nominate a team dedicated to the project and should inform the consortium programme manager about the name/names of this key staff.

Time Schedule & Workpackage Description:

– The partners will work to the agreed time-schedule & work-package description.

– Both, the time-schedule and the work-package description laid out in this Call shall be further detailed as required and agreed at the beginning of the project.

Progress Reporting & Reviews:

– Three progress reports will be written over the duration of the programme. For all work packages technical achievements, time schedule, potential risks and proposal for risk mitigation will be summarised.

– Regular coordination meetings shall be conducted via telecom where appropriate.

– The partners shall support reporting and agreed review meetings with reasonable visibility on its activities and an adequate level of information.

– Quarterly face to face review meetings will be held to discuss progress.

Task 2: Fuel injector parametric model

A fully featured lean burn airblast fuel injector will be parameterised and modelled in Siemens NX. The geometry model will be built to enable its easy extension to different topologies. The geometry will be defined using either objects or standard features. An NX Open C++/C# approach will be relied upon to generate analysis models. Parametric modelling will be used for both the gas and fuel washed surfaces. A preliminary design spreadsheet will be used to instantiate the fuel injector geometry model automatcally.

Task 3: Aerodynamic analysis

An airflow network model will be set up automatically. The airflow network tool will be Flownet. The model will allow estimation of the effective area of the various airflow passages based on a preexisting database of discharge coefficient correlations.

A CFD model of the fuel injector aerodynamics will be automatically built using a feature-recognition approach for identification and tagging of surfaces. To start with, the injector will be simulated as plenum fed and discharging into a plenum. This geometry allows for direct comparison with atmospheric rig tests. In a subsequent phase, the injector will be modelled as installed in a combustor head. As such, it will be affected by more realistic upstream and downstream boundary conditions. The grid generation tool will be either ICEM-CFD or Boxer. The CFD tool will be PRECISE-UNS. The CFD calculations will allow deriving the injector effective area as well as details of the aerodynamics.

Task 4: Fuel gallery fluid dynamic analysis

The geometry master model will be used to generate a geometry model to be used for the CFD simulation of the fuel passages. The same grid generation tools indicated in task 3 will be used. The automatically generated CFD model will allow assessing the fuel passage design.

Task 5: Thermal analysis

A finite element model of the fuel injector for thermal analysis will be set up automatically. SC03 is the finite element solver to be used. For the grid generation, either NX or SC03 will be used. The design system will automatically extract the thermal boundary conditions from the CFD models described in the previous tasks.

Task 6: Demonstration of multidisciplinary optimisation capability

The building blocks of the design system developed as part of this programme will be used in an Isight work flow to demonstrate the ability to carry out multidisciplinary optimisation. The system will have to be able to run in parallel on a number of processors.

2. Special skills, certification or equipment expected from the applicant

- Experience in NX Open C++/C#
- Experience in the use of Flownet, PRECISE, SC03, ICEM-CFD/Boxer, Isight
- Experience in computational methods for support of aero-engine combustor design
- Experience in feature-based surface tagging
- Experience in optimisation methods

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Management report	Report will be written to summarise the project management of the programme, including deliverables, level of spend and dissemination	T0 + 18 months
D2	Injector parameterisation	Parametric NX model of the fuel injector available. Report describing the functionality delivered	T0 + 8 months
D3	Aerodynamic analysis	Demonstration of aerodynamic analysis based on automatic generation of Flownet and CFD model. Report to summarise the work.	T0 + 12 months
D4	Thermal analysis	Demonstration of automatic generation of thermal analysis.	T0 + 15 months

		Report to summarise the work	
D5	Fuel injector design optimisation	Demonstration of multidisciplinary optimisation of fuel injector. Report to summarise the work.	T0 + 18 months

4. Topic value (€)

€ 500,000 [five hundred thousand euro]

Topic Description

CfP topic number	Title		
JTI-CS-2014-01-SAGE-06-011	Design methods for accurate combustor wall temperature	**Start date**	T0
		End date	T0 + 18 months

1. Topic Description

Main goals

The SAGE6 Demonstration Project aims to develop and mature a lean burn combustion system suitable to civil aerospace up to TRL6. This will eventually be done via a demonstrator engine project involving ground level and flight tests of a representative lean burn system in a realistic environment.

Lean burn technology is maturing and the potential to reduce NOx emission by burning lean has been demonstrated. The lowest emissions can be achieved if the cooling flow is reduced to a minimum. However, as a result of increasing engine cycle efficiencies core temperatures increase, which implies that more air for wall cooling is required. An accurate predictive capability of wall temperature would enable optimising the required cooling air to a minimum, while also ensuring that wall temperatures are low enough to ensure sufficient part life.

This project aims to improve the predictive capability of combustor wall temperatures and consequently the life of combustor walls. To validate the developed methodology accurate measurements will performed at well-defined test rig conditions. The test rig has to be optically accessible, so that non-intrusive measurement techniques can be applied. The measurements will include accurate wall surface temperatures as well as near wall gas temperatures and velocities. Furthermore, the measurements will have to be performed on a sample impingement effusion tile.

To start with numerical tools will be applied to predict metal wall temperatures using different currently available turbulence and combustion models. Subsequently the predictive capability of the different models and approaches will be assessed. The near wall region has to be resolved very well, and further model development will be required. Special attention has to be paid to how to transfer the CFD data to the finite element thermal analyses to make the two predictive approaches consistent. In the end the developed methodology will be applied to an aero engine combustor and results will be compared with available wall temperatures.

The work proposed here will complement the existing lean burn demonstrator programme. Although the cooling air flow budget is usually defined early on in the combustor design process and this leads to definition of the tiles bulk porosity, thermal issues are often in the form of 2D hotspots due to peculiarities of the combination of cold and hot side conditions. The impingement-effusion cooling style provides the flexibility to enable local cooling of the hot spots. These design modifications can be embedded at a relatively late stage of the design and still have an impact on the combustor durability. Thermocouple and thermal paint measurements made as part of the lean burn demonstration programme will be used to estimate tile life in conjunction with the advanced methods proposed to be developed here.

Task 1: Management

Organisation:

– The partners shall nominate a team dedicated to the project and should inform the consortium programme manager about the name/names of this key staff.

Time Schedule & Workpackage Description:

– The partners will work to the agreed time-schedule & work-package description.

– Both, the time-schedule and the work-package description laid out in this Call shall be further detailed as required and agreed at the beginning of the project.

Progress Reporting & Reviews:

– Three progress reports will be written over the duration of the programme. For all work packages technical achievements, time schedule, potential risks and proposal for risk mitigation will be summarised.

– Regular coordination meetings shall be conducted via telecom where appropriate.

– The partners shall support reporting and agreed review meetings with reasonable visibility on its activities and an adequate level of information.

– Quarterly face to face review meetings will be held to discuss progress.

Task 2: Detailed experimental study of near wall gas temperatures and velocity of reacting, together with accurate wall surface temperature measurements

Detailed experimental validation experiments have to be performed at realistic aero gas turbine conditions. The measurements should provide both velocity field data near the wall as accurate temperatures (within a few degrees) using non-intrusive measurement techniques. Simultaneously the 2-D wall surface temperature shall be measured with high accuracy, also using a non-intrusive measurement method. The wall surface temperature measurement has to be high resolution and time-dependent up to a frequency of 100 Hz. The measurements have to be performed in a combusting environment. The test rig and the measurement techniques should already be available, and the applied method should be demonstrated. The Topic Manager will provide a wall tile (typical dimensions are 20cm) on which the detailed measurement analyses should be performed. Tiles will be provided with and without thermal paint, so that under the same conditions also the conventional method using thermal paint can be performed and the results compared with the more accurate temperature measurements.

Task 3: CFD analysis

The objective is to determine possible numerical and model uncertainties when predicted near wall velocities and temperatures. Different turbulence models shall be applied, including RANS and LES models, and results should compared with measurements data. The CFD computations have to be performed including combustion models based on tabulated chemistry to include sufficient chemical information, but with affordable computations effort, which are representative of modelling approaches used in gas turbine CFD simulations. Furthermore, the near wall flow and heat transfer should be studied in detail. Among the different numerical approaches the current industrial practice should be included, such that recommendations for improvement can be provided.

Task 4: Finite Element and themal stress analysis of the combustor tile

For the finite element analyses and combined thermal stress analyses the near wall temperatures of the CFD computations should be used, as well as the heat transfer coefficients from CFD. The wall surface and predicted metal temperature should be compared with the experimental rig test results. Also here the same industrial practice should be followed, as well as alternative approaches which might improve the accuracy of the predictions. Radiative fluxes have to be estimated and accurate estimations of the emissivity of the tiles and or coatings have to be made. Preferable the emissivity has to be measured.

Task 5: Development of CFD models and or practices to improve the predictive capability of combustor wall temperatures.

This work should be done in close cooperation with the ITD owner, and the models should be incorporated into the in-house CFD code of the industrial partner, which is based on a pressure based incompressible finite volume approach. Subsequently the developed models and methodology shall be used to predict wall temperatures of aero gas turbine combustors. The predicted wall temperatures will next be compared with thermal paint results.

2. Special skills, certification or equipment expected from the applicant

- Experience in experimental techniques for non-intrusive gas velocity and temperature
- Existing combustion rig facility

- Existing measurement equipement and techniques for non-intrusive velocity and temperature measurements in a combusting environment
- Existing measurement equipement and demonstrated track record of capability to measure wall surface temperatures at high accuracy and time resolved
- Experience in cooling modelling methods
- Experience in design and analysis methods for aero-engine combustors
- Experience in thermal stress analyses.
- A track record in combusting CFD computations for aero-engine combustors, including combusting Large Eddy Simulations with focus on near wall modelling in combination with tabulated combustion approaches.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1a, D1b	Management report	2 reports will be written to summarise the project management of the programme, including deliverables, level of spend and dissemination	T0 +9 months, T0+18 months
D2	Experimental results of near wall temperatures and velocities	Report and data of non-intrusive reacting near wall velocities and temperatures	T0 + 12 months
D3	Experimental wall surface temperatures	Report and data of averaged and time resolved temperature measurements	T0 + 18 months
D4	CFD analyses of test rig	Report and CFD data of modelled test rig	T0 + 12 months
D5	Thermal stress analyses of test rig	Report and data of thermal stress analyses of test rig	T0 + 14 months
D6	Improved method to predict combustor wall temperature	Validated approach to model combustor wall temperatures, demonstrated on aero gas turbine combustor.	T0 + 18 months

4. Topic value (€)

€ 1,500,000
[one million five hundred thousand euro]

Clean Sky – Smart Fixed Wing Aircraft

Identification	ITD - AREA - TOPIC	topics	VALUE (€)	MAX FUND (€)
JTI-CS-SFWA	**Clean Sky - Smart Fixed Wing Aircraft**	**10**	**7.615.000**	**5.711.250**
JTI-CS-SFWA-01	*Area01 – Smart Wing Technology*		**1.200.000**	
JTI-CS-2013-03-SFWA-01-054	MEMS Accelerometer – Miniaturisation of the analog electronics in ASIC(s)		800.000	
JTI-CS-2013-03-SFWA-01-055	Miniaturization of digital processing function for a MEMS pendulous accelerometer		400.000	
JTI-CS-SFWA-02	*Area02 - New Configuration*		**1.845.000**	
JTI-CS-2013-03-SFWA-02-044	NLF Wing High Speed Performance Test		1.500.000	
JTI-CS-2013-03-SFWA-02-045	Camera Development for In-Service Monitoring of LE Contamination		145.000	
JTI-CS-2013-03-SFWA-02-046	In-service monitoring of Leading Edge Contamination and Damage		200.000	
JTI-CS-SFWA-03	*Area03 – Flight Demonstrators*		**4.570.000**	
JTI-CS-2013-03-SFWA-03-015	Jigs and Fixtures for Assembly of the Laminar Wing at the “BLADE” Flight Dest Demonstrator Final Assembly Line		900.000	
JTI-CS-2013-03-SFWA-03-016	Wing Tooling for the BLADE Flight Test Demonstrator Final Assembly Line		300.000	
JTI-CS-2013-03-SFWA-03-017	In-Flight Local Surface Deformation Measurements by Means of Reflectometry and Shadow Casting		640.000	
JTI-CS-2013-03-SFWA-03-018	Design, Manufacturing, Qualif.& Assy of an improved NLF Wing LE & Upper Cover Flight Test Article		2.200.000	
JTI-CS-2013-03-SFWA-03-019	Miniaturized remote acquisition unit for optical sensors		530.000	

Topic Description

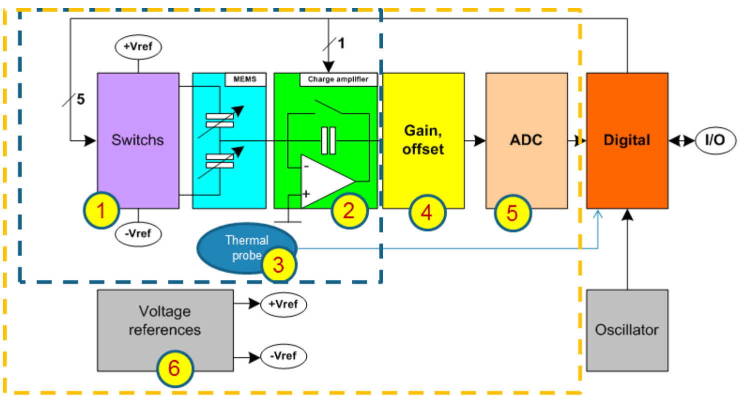
CfP Topic Number	Title		
JTI-CS-2013-03-SFWA-01-054	MEMS Accelerometer – Miniaturisation of the analogue electronics in an Application Specific Integrated Circuit (ASIC)	Start Date	06-2014
		End Date	09-2016

1. Topic Description

Very small inertial measurement units (IMU) are necessary for measuring aircraft wing deformation during flight. The size of the core of MEMS based accelerometer is few millimetres in size. Highly integrated electronics is also required for wing integration purposes.

The goal of this CFP is to demonstrate a step forward in analog electronic integration with respect to maturity level, miniaturization and reduced power consumption without any penalty in performance. For this purpose an analog ASIC development approach is required for the close loop of the pendulous MEMS accelerometer (see the following functional drawing):

- Digital functions and the MEMS are not included in the ASIC
- blue rectangle shows mandatory functions for the ASIC (functions N°1, 2 and 3)
- Yellow rectangle shows all possible functions concerned by the integration analysis (functions n° 1 to 6).



Functions :
1. High performance switches (mandatory)
2. Charge amplifier (mandatory)
3. Temperature probe (mandatory)
4. Gain and offset
5. Analog to Digital Converter (ADC)
6. Voltage reference: typical 25V

The main activities that have to be performed by the applicant are:
- **Specification analysis** (including DO254 and SEU/MBU requirements) **and feasibility study** (assessment of technological solutions even for the economic part (NRC and RC)):
  - Analysis of the specifications and if necessary of the results of our mock-up (discrete electronics),
  - Technology assessment and proposal of choice solutions (ASIC technology selection and integrated list of functions),
  - Economic assessment of the full development,
  - Feasibility synthesis for Go-ahead milestone, Compliance matrix and Specification adjustment,
  - Preliminary Statement of work and management plan.

The following activities depend on the results of the feasibility study and the subsequent go-ahead decision of the SFWA-partner. Therefore the following activities may eventually not be

performed.

- **Project organisation:**
    - Development and management plan
    - Documentation plan
- **Development of the ASIC**
    - ASIC design (simulations…)
    - Manufacturing and delivery of samples
    - Validation of the design and samples delivery
    - Test at component level
- **ASIC correction:** A second run of the ASIC design has to be included in the applicant's offer. This 2nd run will include all improvements necessary for any correction which was revealed by the validation of the first run (applicant component level testing and also SFWA partner testing).
    - ASIC design evolution,
    - Manufacturing and delivery of new samples,
    - Validation and testing of the component, samples delivery.

Target life-time of the unit is 30 years after delivery. The applicant has to prove compliance to this target including the relevant ageing parameters.
Quantity for economic analysis: 8000-15000. 25 years supply. The CfP only includes samples delivery (CfP-topic include delivery of 50 samples).
ITAR free technology is mandatory.
Currently a discrete mock-up is under testing. The Mock-up results will be available in April-May 2014; the specification for the CfP will be updated with these results.

Support is provided by the SFWA partner during all the applicant activities but especially during specification analysis and architecture design, participation in design reviews and impact analysis of the functional testing.

2. Special Skills, Certification or Equipment expected from the Applicant

- The applicant has to provide evidence of industrial experience in analog ASIC development for high performance sensors and the ability to manage such a project for aeronautical applications.
- If fabless, the applicant has to provide evidence of industrial experience in managing fabrication in an external foundry for small quantities and long term delivery.
- The applicant has to have a full ISO 9001 & 14001 certification.

3. Major Deliverables and Schedule

Del.	Title	Description (if applicable)	Due
1	Feasibility analysis report	- Specification analysis: delivered at M0 - Critical design assessment (simulations results) - Technology assessment vs requirements - Compliance matrix - Risk assessment and mitigation plan - Economic data. Preliminary development and management plan The feasibility analysis report delivers all data for the Go ahead decision of the SWFA partner. M1 = Go Ahead decision from SFWA partner (including ASIC functions selection).	M0 + 3 M
2	Development and management plan	- Working plan including all activities until project end. - Documentation plan - Risk assessment and mitigation plan	M1+1 M
3	Preliminary design report	- Specifications update (feasibility results) at M1+ 0.5 M - Architecture - Risk assessment and mitigation plan update	M1 + 4 M

		- Critical simulation results - Compliance matrix update	
4	Critical design report	- Detailed design - All simulations - Risk assessment and mitigation plan update - Compliance matrix update	M1 + 8 M
5	Samples first step	- ASIC: 50 samples delivery	M1 + 12 M
6	Test Report		M1 + 14 M
7	Final first step report	Including update of delivered documents.	M1 + 15 M
8	Second step	M2 = partner test results (typical: samples delivery + 5 to 6 months) Update of all step 1 documents. - Delivery of 50 samples	M2 + 5 M

Due date: hypothesis for due dates is all analogue functions inside the ASIC (n°1 to 6).

4. Topic value

The total value of biddings for this work package shall not exceed

800.000,-- €
[eight hundred thousand euro]

Please note that VAT is not applicable in the frame of the CleanSky program.

5. Estimated spend profile (k€)

2009	2010	2011	2012	2013	2014	2015	2016
-	-	-	-	-	280	400	120

6. Remarks

- The proposal should document the applicant's skills in analog ASIC for sensors. Skills in fine switch and charge amplifier design are mandatory.
- A more precise ASIC specification can be sent to the applicant after an exchange of Expression of Interest and signature of a non-Disclosure Agreement. Delivery is possible in from January 2014 on through via the CSJU.

Clean Sky Joint Undertaking
SP1-JTI-CS-2013-03-SFWA-01-055

Topic Description

CfP Topic Number	Title		
JTI-CS-2013-03-SFWA-01-055	Miniaturization of digital processing function for a MEMS pendulous accelerometer	**Start Date**	06/2014
		End Date	06/2016

1. Topic Description

Very small inertial measurement units (IMU) are necessary for measuring aircraft wing deformation during flight. The size of the core of MEMS-based accelerometers is few millimetres in size. Highly integrated electronics is also required for wing integration purposes.

The goal of this CFP is to design and deliver samples of a “one-chip” component including all the digital functions involved in the close loop of the pendulous MEMS accelerometer. The selected technology has to meet also Single Bit Upset (SBU) / Multiple Bit Upset (MBU) requirements and DO254 development methodology requirements so that it could be used for all aeronautical applications.

The main activities that have to be performed in this CfP-topic are:

- Feasibility analysis:
    - Specification analysis (compliant to requirements in design assurance guidance for airborne electronics DO254, DAL A and SBU/MBU)
        - If needed, an analysis of the SFWA partner mock-up based on a Field Programmable Gate Array (FPGA) which is currently under development is possible.
    - Technology assessment of different solutions (FPGA or ASIC technology selection),
    - Economic assessment of the full development,
    - Feasibility synthesis for go-ahead milestone.

  A go-ahead decision will be taken by the SFWA partner based on the previous feasibility results.

- Development of the integrated digital component according to D0254, DAL A and SEU/MBU (redundancy management…) requirements.
    - In case of ASIC: ASIC design.
    - In case of FPGA solution: FPGA design.
- Manufacturing (in case of ASIC solution) and validation of the design :
    - Manufacturing of samples in case of ASIC solution.
    - Validation and testing of the component, samples delivery.
    - Correction after test results with delivery of new samples in case of ASIC.

Target life-time of the unit is 30 years after delivery. The applicant has to prove compliance to this target including the relevant ageing parameters.
Quantity for economic analysis: 8000-15000. 25 years supply. The CfP only includes samples delivery (CfP-topic include delivery of 50 samples). ITAR - free technology mandatory.
The SFWA partner mock-up is based on a Xilinx Spartan 6 XC6SLX45FGG484speed-2 component. Mock-up results will be available in April - May 2014.
Support is provided by the SFWA partner during all the applicant’s activities especially during specification analysis and architecture.

2. Special Skills, Certification or Equipment expected from the Applicant

- The applicant has to provide evidence of industrial experience in FPGA and ASIC development for sensors and ability to manage DO254, DAL A and SEU/MBU requirements.
- If fabless, the applicant has to provide evidence of industrial experience managing fabrication in an external foundry for small quantities and long term delivery.
- The applicant has to have a full ISO 9001 & 14 001 certification.

3. Major Deliverables and Schedule

Schedule is different if the solution is ASIC or FPGA.

Del.	Title	Description (if applicable)	Due
1	Feasibility analysis report	- Specification analysis: delivered at M0 - Critical design assessment, - Technology assessment vs requirements - Compliance matrix, - Risk assessment and mitigation plan, - Economic data, - Preliminary development and management plan. The feasibility analysis report delivers all data for the Go ahead decision of the SWFA partner. M1 = Go Ahead (FPGA or ASIC choice).	M0 + 2 M
2	Development and management plan	- Working plan including all activities until project end, - Documentation plan, - Risk assessment and mitigation plan.	M1+1 M
3	Preliminary design report	- Specifications update (feasibility results) at M1+ 0.5 M, - Architecture, - Critical simulation results, - Risk assessment and mitigation plan update, - Compliance matrix update.	M1 + 2 M
4	Critical design report	- Detailed design, - All simulations results, - Risk assessment and mitigation plan update, - Compliance matrix update.	M1 + 6 M
5	Samples first step	- ASIC: 50 samples delivery, - FPGA: code delivery.	M1 + 12 M M1 + 6 M
6	Test Report	- ASIC - FPGA	M1 + 14 M M1 + 8 M
7	Final first step report	Including update of delivered documents.	M1 + 15 M M1 + 9 M
8	Second step	M2 = partner test results (M1+16 or M1+12) Update of all step 1 documents. - In case of ASIC : 50 samples - FPGA: code delivery	M2 + 6 M M2 + 3 M
9	Final Report	In case of ASIC: 50 samples FPGA: code delivery	M2 + 7 M M2 + 4 M

4. Topic value

The total value of biddings for this work package shall not exceed

400.000,-- €
[in words: four hundred thousand euro]

Please note that VAT is not applicable in the frame of the CleanSky program.

5. Estimated spend profile (k€)

2009	2010	2011	2012	2013	2014	2015	2016
-	-	-	-	-	120	200	80

6. Remarks

- The proposal should document the applicant's skills in FPGA and ASIC development.
- A more precise ASIC specification can be sent to the applicant after an exchange of Expression of Interest and signature of a non-Disclosure Agreement via the CSJU.

Topic Description

CfP Topic Number	Title		
JTI-CS-2013-03-SFWA-02-044	**NLF Wing High Speed Performance Test**	**Start Date**	July-2014
		End Date	Dec-2014

1. Topic Description

Introduction

Natural Laminar Flow (NLF) is established as a key Technology Stream within the Smart Fixed Wing Aircraft (SFWA) program. As part of the process to mature that technology to a Technology Readiness Level of 6, that includes flight test and ground based demonstrators, it is intended to perform high Reynolds number experiments in a Wind Tunnel (WT). These WT-based experiments will be addressing issues associated with the impact of surface quality e.g. waves and steps, on the robustness of the region of laminar flow.

A large half model with a span of 1.6m is available from previous wind tunnel tests and includes a fuselage and peniche section, see Figure 1 below.

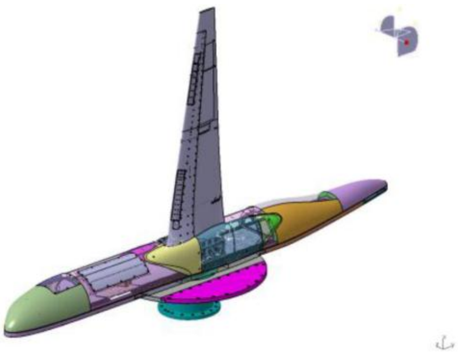


Figure 1: Large half model construction

It is the intention of the SFWA team to seek a WT site that is capable of accommodating this model and performing experiments up to M0.85 and AMC-chord Reynolds numbers below and above 15 mio.

In addition, the model is equipped with simulations of a variety of surface imperfections. The WT facility should be capable of providing and controlling inert gases at steady pressures up to 30 bar.

The high Reynolds number testing is linked with special cleanliness requirements for the model preparation and the wind tunnel flow. Measurements of particle should be done at least at 2 positions in the running flow down to diameters <1µm.

Objectives of WT experiment:

At high Reynolds number the experiment should:

- Provide experimental data about laminar wing performance for a number of selected cruise condition cases
- Provide experimental data related to handling quality at high speed
- Provide transition data with respect to allowable manufacturing tolerances for surface steps and surface waviness for specific cases of Mach number and angles of attack, not tested in a previous campaign
- Provide data to validate CFD predictions on NLF wing designs.
- Allow measurements of transition position, model forces and pressures inside and outside of the model and the fuselage

Model Description

- Overall span ~1.6m, overall length ~ 2m.
- Low sweep NLF wing.
- Wing design point M 0.75, Re 25E6.
- Peniche ~30 mm in height.
- Model is equipped with temperature sensitive paint (TSP) of high surface quality.

The model will require a separate pressure control system and internal pressure measurement.

The model includes a variety of planned surface imperfections.

Instrumentation includes:

- Conventional pressure tappings on both the wing and the half fuselage;
- Internal pressure measurements;
- Temperature Sensitive Paint (TSP) regions on both top and bottom wing surfaces;
- Internal space and attachments to accommodate a 6-component WT balance;
- Accelerometers;
- Assessment of static deflections under load.

The applicant will be required to demonstrate the capability to monitor all these methods and to provide appropriate optical access to the upper and lower wing surfaces for the TSP evaluation. Interpretation of the results will be the responsibility of the relevant SFWA team.

Design and manufacturing of the model has been completed.

Test Programme

The test shall take place in Q3 or Q4 of 2014.

The test shall consist of:

- Initial continuous traverse polars at M 0.73 up to M 0.77 in 0.01 increments to gather pressure data and check lift curve behavior.
- TSP images taken at 5 CLs for various Mach numbers to verify predicted wing behavior.
- Matrix of data points populated with TSP images for prescribed Mach and CL conditions over a range of surface quality conditions;
- Check on alternative Reynolds numbers.
- Preliminary evaluation of buffet boundaries.
- Detailed measurements of surface quality before and after each test block.
- Testing of reference conditions with application of tiny transition bands at different chord positions.

Scope for Innovation

The applicant is required to identify innovative approaches to developing the test matrix and/or data acquisition to minimize the test duration or maximize the volume and quality of data. Real time processing of data could be an advantage.

Concluding Remarks

- A large half model with an NLF wing shall be put into test with respect to high speed performance and handling quality at a wide range of conditions relevant for cruise conditions
- Selected tests shall be performed on allowable surface tolerance requirements for manufacturing and for deformation during flight under loads. .
- Additionally it will provide validation data for NLF design techniques and CFD performance predictions.
- The test program will concentrate on gathering TSP images for transition behavior in the presence of various surface imperfections.

2. Special Skills, Certification or Equipment expected from the Applicant

- Appropriate Certificates and ISO standards.
- Proof/Evidence of capability from former test campaigns including experimental accuracy, repeatability etc.
- Fit to requirements and any specific model handling or mounting requirements.
- Ability to meet both test objectives and test dates.

All applicants should provide recent data on the levels of free-stream turbulence, noise and particulate contamination for the proposed facility at or near the expected test conditions of Mach and Reynolds number. Previous test data on critical N-factor performance of the facility would also be an advantage. Previous experience of testing laminar wings should be reported.

3. Major Deliverables and Schedule

Del. Ref. Nr.	Title	Description (if applicable)	Due
01	Test Readiness Report	A document that shows that all infrastructure and preparatory tests are completed and in place ready for test. Statements of accuracy and proposed test schedule.	M0 + 1 M
02	Final data report	A full compilation of all data acquired	M0 + 5 M

4. Topic value

The total value of biddings for this work package shall not exceed

1.500.000 €

Please note that VAT is not applicable in the frame of the CleanSky program.

5. Estimated spend profile (k€)

2010	2011	2012	2013	2014	2015	2016
-	-	-	-	1.500		

Clean Sky Joint Undertaking
SP1-JTI-CS-2013-03-SFWA-02-045

Topic Description

CfP Topic Number	Title		
JTI-CS-2013-03-SFWA-02-045	**Camera Development for In-Service Monitoring of Leading Edge Contamination**	**Start Date**	Jul-2014
		End Date	Apr-2015

1. Topic Description

The CleanSky Smart Fixed Wing Aircraft Integrated Technology Demonstrator (SFWA-ITD) consortium is interested in understanding the typical level of contamination and minor damage to a wing leading-edge in operational service.

Ideally this would include improved information about the rate of insect or other contamination and its currently unknown dependence on altitude, climatic zones, seasons and environment as well as the cleaning impact of flight through rain, or clouds and any impact of WIPS (Wing Ice Protection System) operation.

In this Call for Proposals topic, interested applicants are requested to develop a compact, autonomously working camera system suitable to record the contamination on the wing leading-edge. The camera system will be installed on a short-range or long-range aircraft at a position to view a section of the wing leading-edge. The system will be used to perform camera recordings during regular operational flights.

Activities to be done by the applicant:

- Develop an autonomous high resolution micro camera system for the installation on an in-service aircraft that can view a section of the wing leading-edge (either a fixed leading-edge or the leading-edge of retracted slats). To ensure an adequate field of view it is proposed to install the camera in a fairing at the fuselage or the pylon.
- The camera system should include the following components: Camera, power system, memory and control system, mount for all components, aerodynamic fairing to cover the complete camera system.
- Ensure easy installation of the camera system and fairing during an overnight check without the necessity of permanent changes to the aircraft structure.
- Select the camera equipment under consideration of the typical operating conditions during the flight.
- The viewing area should be about 500mm span by 250mm chord and the spanwise location should be defined to suit the camera choice and installation.
- Provide the camera and ensure camera view to be of suitable quality to be able to capture insect contaminations within the recordings. A minimum spatial resolution of about 4px/mm will be needed as typical insect residues have a size of about 1mm in lateral direction.
- Provide recording equipment that operates fully autonomously without external power source for the expected number of days away from the home base or until down loading of data is practically possible. Ensure that recording equipment take pictures every 10-60 seconds during climb-out and descent and every 15 minutes during cruise.
- Record current altitude for each image (e.g. GPS sensor) and ensure allocation of the altitude data to the recorded images. Time (GMT) and date to be inserted on the images.
- Ensure easy access to data storage (e.g. wireless data reading to avoid necessity of camera access).
- Test and verify that the system will deliver the required information.
- Certify the camera system for flight.
- The camera development has to be done in cooperation with Airbus and the airline performing the operational flights with installed camera.

Support provided by SFWA consortium partners:

- Agreement of the camera position and installation concept with Airbus and the operator of the aircraft.
- Assessment of a potential aerodynamic impact induced by the camera installation.
- Installation of the camera system.

2. Special Skills, Certification or Equipment expected from the Applicant

The applicant should have the capability to develop, certify and install suitable camera equipment and recording devices on an aircraft.

3. Major Deliverables and Schedule

Del. Ref. Nr.	Title	Description (if applicable)	Due
1	Camera and recording equipment installation proposal	Detailed description and justification of the proposed camera system and its installation. Estimation of the viewable area and the expected quality. Agreement of concept with the consortium and aircraft operator.	M0 + 3 M
2	Intermediate review	Demonstrate current status of camera development. Highlight potential risks and show risk mitigation concept.	M0 + 5 M
3	Delivery of the complete camera system	Delivery of the complete camera system including all specified components.	M0 + 8 M
4	Initial test of camera and recording equipment	Initial test of the camera system to demonstrate that the system will deliver the required information. Demonstration that the camera is working under temperature and pressure conditions occurring during flight. Camera has to withstand the temperature conditions on ground during warm and cold conditions.	M0 + 9 M
5	Final test of camera and recording equipment	Final test of the camera equipment after installation on the aircraft to verify the viewable area, the quality and that the required data can be collected.	M0 + 10 M
6	Detailed documentation	Detailed documentation of the complete camera system including installation details, power and control system and operating instructions.	M0 + 10 M

4. Topic value

The total value of biddings for this work package shall not exceed

145.000,-- €
[One hundred and forty-five thousand euro]

Please note that VAT is not applicable in the frame of the CleanSky program.

5. Estimated spend profile (k€)

2011	2012	2013	2014	2015	2016	2017
-	-	-	120	25	-	-

6. Remarks

The applicant should be aware of restrictions and requirements of subcontracting within CFP contracts.

Topic Description

CfP Topic Number	Title		
JTI-CS-2013-03-SFWA-02-046	**In-Service Monitoring of LE Contamination and Damage**	**Start Date**	Mar-2015
		End Date	Sep-2016

1. Topic Description

The CleanSky Smart Fixed Wing Aircraft Integrated Technology Demonstrator (SFWA-ITD) consortium is interested in understanding the typical level of contamination and minor damage to a wing leading-edge in operational service.

Ideally this would include improved information about the rate of insect or other contamination and its currently unknown dependence on altitude, climatic zones, seasons and environment as well as the cleaning impact of flight through rain, or clouds and any impact of WIPS (Wing Ice Protection System) operation. In addition, the consortium would like to apply different surface treatments and examine the impact of these.

In this Call for Proposals topic, interested applicants are requested to operate a camera system to be installed on an aircraft that can view a section of the wing leading-edge. Camera recordings have to be made during regular operational flights and basic information about each flight has to be noted. These recordings have to be backed-up by specific leading edge inspections when appropriate.

The observation of the insect contamination during the flight is required because cleaning effects due to rain, drying of insects and subsequent ablation of the dry insects due to the surface friction are important information to understand and predict the potential degradation of the flow quality close to the wing leading edge during the flight. A measurement after landing is not representative, but is providing complementary information.

The flights to be performed by the applicant could either be short-range (to increase number of flight cycles) or long-range (to increase operation in different climatic zones and seasons) or more preferably a mixture of both. The duration of the trial should be **at least 12 months** but will depend on the number of flight cycles and the type of aircraft. It is mandatory to cover a full annual period of flight operation i.e. in all seasons.

Activities to be done by the applicant:

- Installation of an autonomous high resolution micro camera on an in-service aircraft that can view a section of the wing leading-edge (either a fixed leading-edge or the leading-edge of retracted slats) during an overnight check. To ensure an adequate field of view it is intended to install the camera in a fairing at the fuselage or the pylon.
- Record the view of the wing leading-edge during each flight. Camera to take pictures every 10-60 seconds during climb-out and descent and every 15 minutes during cruise.
- Record details about each flight, such as date, time, origin and destination, weather conditions during climb-out and descent, cloud level during cruise, use of WIPS, altitude when slats were retracted or deployed.
- For a specific number of flights, to photograph the visible area and count number of insect contaminations to check against camera view.
- Record any cleaning activity performed during the trial period. There should be no manual cleaning of the observed area in addition to the regular cleaning periods in order to avoid non-representative data.
- Perform visual inspection of leading-edge section and record any scratches and gouges before commencement of trial, after every month, and at end of trial.
- First and final inspection of observed surface to be done together with Airbus specialists. Expected duration of about 2-3 hours.
- Application of different surface treatments as defined by SFWA partners.
- Collection of the recordings, data, photos and inspection results for post processing.
- Capturing of the status of the cleaned surface at the beginning and the end of the flight cycle with regard to roughness and potential other surface imperfections. Simple measurements by

a roughness measuring device (Perthometer) and high resolution images are sufficient.

Support provided by SFWA consortium partners:

- Supply of the complete camera system (camera, power system, memory and control system, mount for all components, aerodynamic fairing). The concept of the camera system and the camera location to be agreed with the applicant.
- Service bulletin providing a detailed description of the installation procedure.
- Certification of the camera system for flight.
- Specification of the required information from the tests and inspections.
- New surface treatments to be applied.

2. Special Skills, Certification or Equipment expected from the Applicant

- The applicant should be able to provide a suitable aircraft operating a regular service.
- The applicant should be able to inspect the viewable area, apply surface treatments and collect the required data.

3. Major Deliverables and Schedule

Del. Ref. Nr.	Title	Description (if applicable)	Due
1	Camera installation on an in-service aircraft.	Installation of the provided camera system and aerodynamic fairing during an overnight check. Support initial test of the camera and recording equipment.	M0 + 1 M
3	Initial inspection results	Detailed inspection of viewable area before start of trial. Surface inspection	M0 + 2 M
4	Initial trial test analysis and recommendations	Report showing preliminary results and any recommendations or changes to ensure the success of the test.	M0 + 4 M
5	Trial results	All recorded data, flight information, photographs and inspection results collected from tests in a digital format.	M0 + 16 M
6	Final inspection results	Detailed inspection of viewable area at end of trial. Surface inspection.	M0 + 16 M
7	Final report	Final report describing recorded data incl. flight information and inspection results.	M0 + 18 M

4. Topic value

The total value of biddings for this work package shall not exceed

200.000,-- €
[One hundred and twenty-five thousand euro]

Please note that VAT is not applicable in the frame of the CleanSky program.

5. Estimated spend profile (k€)

2013	2014	2015	2016	2017		
	20	100	80	-		

6. Remarks

The applicant should be aware of restrictions and requirements for of subcontracting within CFP contracts.

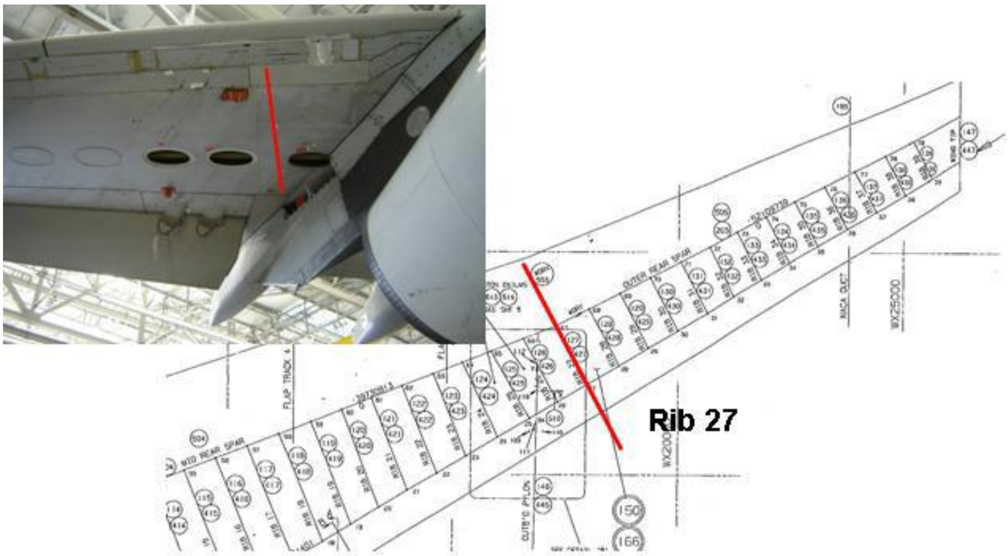
Topic Description

CfP Topic Number	Title		
JTI-CS-2013-03-SFWA-03-015	Jigs and Fixtures for Assembly of the Laminar Wing at the "BLADE" flight test demonstrator Final Assembly Line	**Start Date**	07-2014
		End Date	12-2016

1. Topic Description

Brief description of required tooling
This CfP is asking for conducting the design, manufacture and installation of all jig platforms, staging and operational tooling, plus project tooling for the SFWA laminar flow flight test demonstrator. It is required to perform all stages of the assembly and disassembly of both Port and Starboard outer wing sections of an Airbus A340-300 (see blue wing sections in the figure below).

CfP Topic Description
The SFWA flight test demonstrator aims to validate that a specific wing profile can sustain laminar flow with an acceptable stability versus in flight deformation and contamination. The new outer wing sections to be fitted will have a very accurate profile and high smoothness of the wing surface. These boxes will be dry areas (without fuel) and fully functional with Flight Test Instrumentation. The outer wings' dimensions will be approximately 8.5 m in span length and 4.1m in chord at the wing box root. To accommodate the new outer wings the original outer wings will be removed at Rib 27. A transition structure, which takes up the geometrical differences between the original inner wing and new outer wing, will be assembled in-situ and joined to the inner wing at rib 27. The following figure shows the Rib 27 Datum with the photograph showing its proximity to the outboard engine of the A340-300.



Key Inputs
Upon selection of a preferred bidder the following information will be made available:

- Build philosophy for Final Assembly Lines (FAL) operations
- Aircraft tolerance and laminar wing tolerance requirements
- Frontier drawings
- Datum and laminar wing models / drawings

Key Tooling Requirements

Post-Flight Test tooling to support a build philosophy which includes:-

1. Disassembly of the new outer wingbox from the transition structure.
2. Disassembly of the new inner wingbox transition structure back to the original Rib 27 datum.
3. Restore inner wingbox structure to rib 27 original condition.
4. Wing join-up to restore outer wingbox and inner wingbox to original condition. To facilitate disassembly & assembly operations, two rigid structural jig platform stages are required to be erected at both port and starboard wing positions for the purpose of supporting operational tooling and operator access. The interfaces of the structural jig platform and operational tooling will require to be qualified by laser tracking and positional setting to the airframe reference datums.

General
This preliminary specification is issued to enable potential applicants to submit proposals to the JU for the conception, design, manufacture and supply of the required tooling package, with a breakdown of cost and efforts. Compared to an earlier, topic issued in CleanSky CfP call #9, the topic presented here is building on a substantially updated package of data and requirements emerging from the laminar wing development in 2012 and 2013. It is also including the responsibility of the applicant to install all tooling, platforms and associated staging to carry out the required operations at the Airbus Final Assembling Line facility Toulouse. All tooling should be finally qualified and supplied with detailed inspection reports.

The work package also includes the requirement on the applicant to project manage all stages of supply and installation to meet technical requirements and project milestones.

Applicants must comply with the Airbus processes for tool design and manufacture (ME-Guide-11-522) which covers the design of new tooling from scheming through to production tool drawings and modifications to existing tool drawings, and which shall be provided to the successful applicant during the negotiation phase.

*Handling of customer technical tooling i*s not included in any of the commercial requirements that are covered within formal Purchase Order documentation and Tool Specification.

Lifting & Handling
All manufactured tooling must be compliant with existing Airbus standards and health & safety directives.

The supplier should ensure that the design of any tooling takes into account the elimination or reduction of over-reaching, stretching and working overhead. Ease of loading of any component parts and the subsequent loading and un-loading of the completed assembly must be considered.

Any tooling items that fall outside the Airbus weight limit (25kg) must be supplied with suitable lifting equipment. Particular attention must be given to removing weight where possible whilst still ensuring tooling functionality.

Tooling Design
Tooling designs where possible should embrace innovative designs and new technologies for tooling solutions to achieve project cost reductions and improved efficiency of operations in keeping with a one off or low volume build.

Delivery
The applicant will have full responsibility and charge of transportation of all tooling to the FAL. Refer to section 3. Major deliverables and schedule.

Installation
The applicant will have full responsibility and charge of installation and certify the conformity of all jig platforms, stages and operational tooling with reports and quality documentation.

Refer to section 3. Major deliverables and schedule.

It is expected that all metrology equipment required for the setting, certification and acceptance of the jigs will be provided by the applicant.

2. Special Skills, Certification or Equipment expected from the Applicant

- The applicant should have experience in aeronautical tooling: design and manufacturing.
- The applicant should have experience in the assembly of aeronautical wing boxes.
- The applicant should have good manufacturing and metrological skills in order to supply the required tolerances.
- The applicant should have fluent English manufacturing engineering language and communication skills.
- The applicant should display good knowledge of innovative tooling methodologies which may provide solutions to the unique issues posed by a laminar flow aircraft.

3. Major Deliverables and Schedule

Del. Ref. Nr.	Title	Description (if applicable)	Due
1	Supplier Selection		07-2014
2	Statement of Work	Defined tooling requirement & specification issue	07-2014
3	Design Proposal - CDR	Design proposal Critical Design Review	07-2014
4	Scheme CDR	Design Scheme Critical Design Review and compliance to Airbus ME-GUIDE-11-522	09-2014
5	Detailed Design	Approvals and issue of drawings for manufacture	06-2015
6	Manufacture	Manufacture & acceptance of all required tooling	01-2016
7	Delivery to Site	Jig platform, staging and operational tooling	04-2016
8	Installation	Commissioning and qualifying	05-2016
9	Aircraft	Tooling support during wing refurbishment operations	06-2016

	Refurbishment		
10	Decommissioning	Tooling withdrawal and storage/disposal	12-2016
11	Data and Report	Completion of technical file, qualifying documentation, tool drawings and model data for vaulting/storage. Ref. ME-GUIDE-11-522	12-2016

4. Topic value

The total value of biddings for this work package shall not exceed

900.000,-- €
[nine hundred thousand euro]

Please note that VAT is not applicable in the frame of the CleanSky program.

5. Estimated spend profile (k€)

2014	2015	2016
300	200	400

Clean Sky Joint Undertaking
SP1-JTI-CS-2013-03-SFWA-03-016

Topic Description

CfP Topic Number	Title		
JTI-CS-2013-03-SFWA-03-016	Wing Tooling for the BLADE Flight Test Demonstrator Final Assembly Line	Start Date	06-2015
		End Date	08-2016

1. Topic Description

Introduction

The objective of this CfP topic is the qualification of the geometrical shape and quality of the BLADE laminar wing articles by means of 3D optical measurement of the SFWA High Speed Demonstrator which is focused on Natural Laminar Flow demonstration. For the tests the outer sections of the wing will be replaced with sections suitable for laminar flow as shown in the sketch below.

In support of the High Speed Demonstrator for Passive Laminar Flow Technology (BLADE) flight test programme measurements are required to characterise the NLF wing throughout the test.

Requirements

The measurement system must fulfil two distinct requirements for the flight test campaign

1. To conduct measurements of the full NLF wing surface at the beginning of and throughout the flight test campaign. This will be a large volume measurement of the entire surface, compiled into a single data file for analysis. This will require detailed local measurements of waviness, step, gaps, 3D surface imperfections and profile in an area not larger than 8mx3m.
2. To perform diagnostic measurements of local features throughout the flight test campaign to aid understanding of physical phenomena. This will require detailed local measurements of waviness, step, gaps, 3D surface imperfections and profiles in an area not larger than 800mmx800mm.

Airbus will release specific, proprietary details of the tolerances required to be measured in this experiment, after awarding of the contract. To enable candidates to proceed with their proposal it is requested that evidence of best capability is provided. Measurement examples of representative surfaces are to be presented in any bid including verification of any uncertainties quoted.

- This should include both local measurements (within a 400mmx400mm area) and stitched/compiled measurements up to 8mx3m.
- Evidence of experience of compiling and analysing large data sets will be required showing a clear understanding of uncertainties generated by this process.
- Evidence that any proposed system has confirmed capability against a known standard which is appropriate for the application.

Schedule:

The measurement activity would start in Q4 2015 and finish Q3 2016 with the end of flight tests.
Main events will be:

- Measurement of completed wing attached to the A340 aircraft during up-bend test
- Measurement of the full wing on ground, unloaded prior to commencement of the flight test campaign

2. Special Skills, Certification or Equipment expected from the Applicant

- Measurement of the waviness to the required accuracy is the biggest challenge and may require special equipment and techniques.
- The solution should be capable of scanning large surfaces as quickly and accurately as possible in order to minimise the impact of the measurements on the overall programme deliverables. The computation time for compiling should also be considered in this estimation of cycle time.
- Fully qualified operators and fully certified / traceable equipment to satisfy international standards for high precision, high volume measurements are essential to qualify the measurements taken

3. Major Deliverables and Schedule

Del. Ref. Nr.	Title	Description (if applicable)	Due
1	Pre Flight #1	Pre-flight measurement of the full wing under load	M0 + 3 M
2	Pre Flight #2	Pre-flight measurement of the full wing on ground without load	M0 + 6 M
3	Inter Flight #1	Full wing measurement on ground without load	M0 + 9 M
4	Inter Flight #2	Full wing measurement on ground without load	M0 + 15 M
5	Inter Flight #3	Ad Hoc measurement in support of local measurements for diagnostic purposes	M0 + 10 M
6	Inter Flight #4	Ad Hoc measurement in support of local measurements for diagnostic purposes	M0 + 12 M
7	Inter Flight #5	Ad Hoc measurement in support of local measurements for diagnostic purposes	M0 + 14 M

4. Topic value

The total value of biddings for this work package shall not exceed

300 000,-- €
[in words: three hundred thousand euro]

Please note that VAT is not applicable in the frame of the CleanSky program.

5. Estimated spend profile (k€)

2014	2015	2016
-	200 000	100 000

Clean Sky Joint Undertaking
SP1-JTI-CS-2013-03-SFWA-03-017

Topic Description

CfP Topic Number	Title		
JTI-CS-2013-03-SFWA-03-017	**In-Flight Local Surface Deformation Measurements by Means of Reflectometry and Shadow Casting**	**Start Date**	june-2014
		End Date	june-2016

1. Topic Description

CONTEXT

This Call for Proposal is linked to the Flight Testing activities of the SFWA High Speed Demonstrator of Passive Laminar Flow Technology Demonstrator (BLADE). In particular, it is related to the necessary in flight measurement of the wing local deformation.

BLADE demonstrator (A340-300 vehicle with modified outer wings)

Indeed, Natural Laminar Flow is one of the key technologies to reduce aircraft drag and fuel consumption. However, its application on commercial aircraft requires manufacturing of a very high surface quality and a minimum of surface quality degradation during flight. Any defect (waviness, steps, gaps, insect debris...) could trigger the transition of the boundary layer to turbulent conditions thus cancelling the benefits of laminarity.

For the in-flight wing local deformation measurement of (BLADE), it is necessary to implement the following solutions.

Nota :

- The technologies selected and designed are nearly tangential reflectometry and shadow casting.
- The reflectometry measurement is based on the measurement of the deformation of a pattern after nearly tangential reflection on the surface under observation. The set-up allows the installation on an aircraft without affecting the aircraft aerodynamic and structural characteristics.
- Shadow casting is based on the principle of the measurement of the shadow length that develops around a step or gap when exposed to quasi tangential illumination.
- These two techniques will allow to measure respectively, on the upper wing surface, waviness, steps and gaps.

MEASUREMENT REQUIREMENTS

The measurement system, which is available as principle laboratory setup, shall be implemented in order to quantitatively measure surface waviness, steps and gaps of the laminar wing surface during flight testing.

- The area of interest for the local surface measurement is the full span of the laminar wing upper surface, in chord-wise direction limited between the leading edge and rear spar. The highest priority of the measurement has to be laid on the area located between the wing leading edge and the front spar.

- The spatial resolution in the area of interest shall be (chord-wise) b/a=0.002 with typical values for the average wavelength 100mm < a < 200mm, and b the wave amplitude
- Steps and gaps (in line of flight and across line of flight) of 0.1mm on the full outer wing cover and the leading edge
- The surface measurement technique shall be able to provide measured data in a patch of at least 400cm^2. The size of the measurement area offered by the applicant will be part of the selection criteria.
- Effects like density gradients in the flow may affect optical measurement techniques and have to be considered.

TASKS
The following tasks have to be performed:
- Manufacturing of the instrumentation designed
- Their optimization and fine tuning in order to reach the necessary overall system performance
- Optimization of the software and measurement process (particularly the implementation of a pertinent marking solution)
- Their integration into the A/C
- Their fine tuning and optimization in order to reach the overall system performance during the flight test campaign
- Development (design & manufacturing) of an on-board real-time data processing / analysis tool
- Design and manufacturing of a ground station for differed time data processing.

SCHEDULE
The activity would start in June 2014 and finish in mid-2016.

Main periods will be:
- Integration of measurement system in A/C in 2015
- Flight tests and analysis in 2015-2016

2. Special Skills, Certification or Equipment expected from the Applicant

The measuring device shall demonstrate a Technology Readiness Level of 5 for the milestone corresponding to the Critical Design Review of the project (today envisaged mid of 2014).

3. Major Deliverables and Schedule

Del. Ref. Nr.	Title	Description (if applicable)	Due
1	Hardware set 1	All components of in-flight measuring devices	M0 + 8 M
2	Software & processing means	On-board processing tool & marking solution	M0 + 12 M
3	Hardware set 2	On ground processing means	M0 + 16 M

4. Topic value

The total value of biddings for this work package shall not exceed

640.000 €
[six hundred forty thousand euro]

Please note that VAT is not applicable in the frame of the CleanSky program.

5. Estimated spend profile (k€)

2010	2011	2012	2013	2014	2015	2016
-	-	-	-	100	400	140

Clean Sky Joint Undertaking
SP1-JTI-CS-2013-03-SFWA-03-018

Topic Description

CfP Topic Number	Title		
JTI-CS-2013-03-SFWA-03-018	**Design, Manufacturing, Qualification and assembly of an Improved NLF wing leading edge and upper cover flight test article**	**Start Date**	July-2014
		End Date	Nov-2016

1. Topic Description

Introduction

Natural Laminar Flow [NLF] is one of the key technologies to reduce Aircraft drag and fuel consumption. However, its application on commercial aircraft requires achieving very good tolerances surface quality. Any defect (waviness, steps, gaps...) could trigger the transition of the boundary layer to turbulent conditions. That is why ensuring a high wing surface quality and low tolerances with respect to the wing geometry, in particular in the area of the leading edge and upper cover, is of paramount importance during all times of flight operation.

The SFWA "BLADE" project, which includes a major flight test campaign with NLF outboard test wings attached to either side of the Airbus A340-300 test aircraft, aims at validating in representative conditions the fact that such technical characteristics can be met for wings upper covers & leading edges using industrial processes.
The baseline for BLADE starboard wing upper cover comprises a metallic leading edge and a CFRP upper cover. The joint between leading edge & upper cover will constitute a specific design & manufacturing focus to meet the required tolerances.

In a previous Call for proposal activity, design and manufacturing of a starboard wing leading edge (LE) and upper cover for this laminar wing flight demonstration has been started and progressed to an intermediate status, as outlined in a following paragraph.
A particular feature of this leading edge and upper cover design is the demanding level of surface quality and assembling tolerances, which are required to keep a laminar boundary layer. These tolerances will be made available in a dedicated dossier.

This CfP-topic is addressing activities to build on the status of the design and build of the starboard wing LE and upper cover achieved so far, and to add further elements of an extended scope, resulting from experiences made during the past two years. The key activities to be addressed in this CfP-topic are:

- Improve the design concept and the manufacturing quality to ensure achieving the tolerance requirements for the NLF wing over the upper cover
- Progress and finalise design in order to achieve C maturity, following criteria defined in BLADE work package. This activity comprises, but is not limited to:
  - Stress justification, including samples testing as defined in stress test plan
  - Surface recovery demonstration via agreed test plan, to secure a large extension of laminarity in flight
- Further progress design up to DFM (Data For Manufacturing)
- Manufacture starboard upper cover & leading edge, including FPQ articles
- Deliver permit to fly documents related to starboard upper cover & leading edge
- Support wing box assembly & wing fitting on the aircraft, for matters related to starboard upper cover & leading edge.
- Support operations during flight test campaign if required (repairability analysis, repairs operations)

It is expected that the information provided in this topic description are sufficient to prepare a proposal. For reasons of intellectual properties, further details with respect to geometries, tolerances, loads, materials and interfaces will be provided after the selection process.

Wing geometry

Total span is around 8,5 meters for a chord (leading edge+ upper cover) between 2 meters and 4 meters.

Description

This CFP includes the review and, where required improvement of the detailed design and manufacturing of the following starboard outer wing parts:

- Upper cover skin (composite)
- Stringers (composite)
- Rib feet (metallic)
- Spar cap (composite)
- D-nose (metallic)
- Leading edge ribs (metallic)
- Sub-spar (tbc) (metallic)
- Joint/attachment brackets (metallic)

1 - It includes, for design:

- Upper covers and LE Ribs FE-Models, to be delivered to Airbus for validation and integration in an overall outer wing and A/C FEM
- Design (drawings and models) up to drawing for manufacturing "DFM".
- Stress analysis and results.
- Inputs to DMU (CATPart files + CATProduct, CATIA V5 R18 format), to be delivered to Airbus Configuration Manager for integration in the overall outer wing and A/C digital mock-up (DMU).
- Liaising with Partners in charge of interfacing components
- Liaising with Airbus for FTI integration
- Contribution to Flight Clearance dossier (incl. V&V applied to manufactured parts)

Note: Any modification or upgrade from the actual design, which is the reference to start from, or other proposed innovative concepts will need to comply or exceed TRL3 (Technology Readiness Level 3) to demonstrate it is mature enough to be applied on the flight demonstrator.

2 - It includes, for manufacturing:

- Drawing sets to support DFM (Data for Manufacturing)
- Purchase of material
- Manufacturing processes and tooling description & qualification if necessary
- Component manufacturing, including support to FTI installation (e.g.: flush mounted sensors, pressures taps, hot films, t° sensors, etc…).
- Assembly of sub-components
- Verification of waviness achievements links with TDD.
- Contribution to Flight Clearance dossier (incl. V&V applied to manufactured parts)

The final surface treatment of the leading edge and upper cover, i.e. the painting, is not part of this topic except primer coating. However, tolerances reached at starboard upper cover & leading edge delivery shall meet the set tolerances compatible with laminarity. Any surface recovery measure, if required to re-establish the surface quality at or after the assembly to the test aircraft, is part of this CfP-topic.

3 - it includes also logistics aspects:

- Choice of transportation mean(s)
- Any tooling needed for transportation (design/manufacturing/supply)
- Component transportation to assembly site, with, if needed, support from Airbus transportation expertise.
- Accompaniment in component delivery and handling during wing assembly
- Accompaniment in component delivery and handling when mounting the wing test articles to the aircraft
- Accompaniment / "stand-by" consultant support during the flight test campaign

Inputs:

- Surface Quality Requirements
- FE-Models, including loads

- Data Basis for Design
- Applicable Documentation List
- Design principles and stress methods requirements
- Starboard wing upper cover & leading edge requirements
- Outer wing jig shape
- Material data
- FTI installation requirements
- Design DMU data
- SPAN line opening with Airbus
- Project development plan
- Configuration management plan

Outputs:

- All material supporting successful C maturity, i.e. (not exhaustive)
  - Drawing sets and inputs for DMU (CATPart files) in C mat & DFM standards
  - Stress dossier & FE models
  - Requirements V&V
- DFM data
- Outer wing components: upper covers and LE
- Transportation to Aernnova assembly site
- Inputs for Flight Clearance dossier & permit to fly
- Support on concessions

2. Special Skills, Certification or Equipment expected from the Applicant

- The applicant shall have a sound industrial background in manufacturing and designing upper cover & leading edge parts.
- The applicant has to have a full ISO 14001 certification.
- Given the short amount of time available, it is preferable that the applicant comply with Airbus procedures.
- The applicant must be ready to sign a confidential agreement with Airbus with respect to detailed data exchanged on the test aircraft, materials, processes, etc.
- The applicant is capable to cover peak loads with respect to adequately skilled resources capacity, work shop space and tooling adequate to the manufacturing and testing of large piece CFRP components.
- Experience with first flight certification process is mandatory
- The applicant shall be DOA & POA holder

3. Major Deliverables and Schedule

Del. Ref. Nr.	Title	Description (if applicable)	Due
02	C-maturity review	3D design data (CATIA r21), design principles, Interface & Frontiers drawings, stress dossiers, requirements V&V (C maturity deliverables are all identified in Airbus BLADE WP3 C maturity checklist)	30/08/2014
05	Components delivery	Delivery to assembly line	30/10/2014
06	Flight clearance dossier		30/09/2014
07	Assistance at starboard Wing Assembly	Expected from 10/2014 to 04/2015	
08	Assistance at wing assembly to test aircraft	Expected from 04/2015 to 09/2015	
09	“Stand by” Consultance during flight test campaign	Provision to be made from 09/2015 to 09/2016	

4. Topic value

The total value of biddings for this work package shall not exceed

€ 2.200.000
[two millions two hundred thousand euro]

Please note that VAT is not applicable in the frame of the CleanSky program.

5. Estimated spend profile (k€)

2010	2011	2012	2013	2014	2015	2016
-	-	-	-	1.950	200	50

Topic Description

CfP Topic Number	Title		
JTI-CS-2013-03-SFWA-03-019	**Miniaturized Remote Acquisition unit for Optical sensors**	**Start Date**	July-2014
		End Date	Oct-2016

1. Topic Description

Context:
The aeronautical industry tends to decrease impacts of the flight test instrumentation (FTI) in their aircraft by reducing:
- The weight / volume / power consumption of the equipment,
- The complexity of current Flight Test Instrumentation (FTI, wiring, EMC, …)
- The installation, configuration and FTI validation and verification (V&V) efforts.

The benefits of using optical technologies to replace wired electrical sensors are:
- A large workload reduction for FTI installation (sensors multiplexing)
- Suitable for all aircraft areas (including ATEX and highly EMC exposed areas) without any additional protections
- Compliance with future regulations (energy levels in fuel tanks)
- Absolute electromagnetic immunity: no restrictions on fibre routing (segregation) and sensor localizations.

Object of current proposal:
The aim is to develop a miniaturized acquisition unit for optical sensors to be remotely used for strain, pressure and temperature measurements on optical fibres in cabin and non-cabin areas.

System Requirements:

The system should fulfil the following requirements:
- Acquisition of 8 optical channels
- Wide bandwidth wavelength > 100 nm
- > 2000 samples per second
- High spatial resolution accuracy (2pm = picometer)
- Dimensions less than: 250mm x 120mm x 75mm
- Power consumption: <50W
- Use in A/C harsh environment and DO160 compliant
- Operating Temperature: -55°C to 105°C
- ATEX compliant (EU guidelines for *Atmosphere Explosibles*)
- Data output: Ethernet and optical output (optional)
- Interrogator must be able to address a chain of sensors on a same fibre of such physical quantities:
  - Temperature:
    - Range from -60°C to 300°C
    - Range from: 0°C to 700°C
  - Pressure:
    - 0 to 1.5 bar
    - Accuracy < 1mbar
    - Temperature compensated between -50°C to +80°C
  - Strain:
    - Range: +/- 2500 µstrains with a 20 µstrain accuracy
    - Range: +/- 6000 µstrain with a 100µstrain accuracy
    - Both temperature compensate

Tasks:

The following tasks have to be performed:

- A feasibility study of the concept with a preliminary architecture
- The design of a flight worthy system
- Development of demonstrators to validate the feasibility and reliability of the concept at sub components level and development of specific software
- Optimization of the concept, the architecture and lay-out of the system
- 1st prototype for on-ground tests
- Laboratory metrological tests and validation
- On-ground tests representative of in-flight environment
- 2nd industrial prototype for on-ground and in-flight tests
- Manufacturing of a first serial product for in-flight application

SCHEDULE
The activity would start in June 2014 and finish in September 2016.
Main periods would be:

- Demonstration of feasibility on mock-up before mid-2015
- Prototyping and lab testing in 2015
- In-flight test campaign on a 2nd prototype in 2016
- 1st serial product by end of the project for Q3 2016

The measuring device shall demonstrate a Technology Readiness Level of 6 by the end of the project, with successful in-flight application.

2. Special Skills, Certification or Equipment expected from the Applicant

The applicant(s) should have an expertise in:

- Optical component design and development
- Mechanical & system integration studies
- Measurements techniques for strain, temperature and pressures
- Lay-out of measurement equipment for flight testing
- Lab testing for harsh environment conditions measurements

3. Major Deliverables and Schedule

Del. Ref. Nr.	Title	Description (if applicable)	Due
1	Prerequisites for a measurement setup	Synthesis of the requirements provided by Airbus and ways to reach the objectives	M0 + 1 M
2	Feasibility Study	Feasibility study and preliminary architecture	M0 + 4 M
3	Demonstrators	Demonstration at subcomponent level + architecture of prototype	M0 + 10M
4	1st Prototype	1st on-ground test prototype	M0 + 18 M
5	In-flight Prototype	Final prototype to be tested in-flight	M0 + 22 M
6	Serial Product	1 serial product	M0 + 26 M
7	Final Report	Synthesis of the work	M0 + 27M

4. Topic value

The total value of biddings for this work package shall not exceed

€ 530.000
[five hundred thirty thousand euro]

Please note that VAT is not applicable in the frame of the CleanSky program.

5. Estimated spend profile (k€)

2010	2011	2012	2013	2014	2015	2016
-	-	-	-	50	260	220

Clean Sky – Systems for Green Operations

Identification	ITD - AREA - TOPIC	topics	VALUE (€)	MAX FUND (€)
JTI-CS-SGO	**Clean Sky - Systems for Green Operations**	**11**	**6.290.000**	**4.717.500**
JTI-CS-SGO-01	*Area-01 - Definition of Aircraft Solutions and explotation strategies*		**0**	
JTI-CS-SGO-02	*Area-02 - Management of Aircraft Energy*		**4.640.000**	
JTI-CS-2013-3-SGO-02-052	Electrical Starter / Generator disconnect system		600.000	
JTI-CS-2013-3-SGO-02-066	HVDC fuses design, development, validation and integration		800.000	
JTI-CS-2013-3-SGO-02-083	Adaptable power density coating for energy efficient heating of cockpit and cabin		1.000.000	
JTI-CS-2013-3-SGO-02-084	Optimizing power density of aircraft inverter by combining topology and PWM-patterns		500.000	
JTI-CS-2013-3-SGO-02-085	Development of a composite sleeve for spatial separation of rotor and stator of an electrical motor		300.000	
JTI-CS-2013-3-SGO-02-086	Development of actuator components made by alternative metal injection molding (MIM) process		200.000	
JTI-CS-2013-3-SGO-02-087	Technology development and fabrication of high-temperature high-frequency capacitors for power switch integration		440.000	
JTI-CS-2013-3-SGO-02-088	Accelerated Life Testing of Electrical Motor Drives		800.000	
JTI-CS-SGO-03	*Area-03 - Management of Trajectory and Mission*		**200.000**	
JTI-CS-2013-3-SGO-03-027	Provision of a cross platform development tool suite for high performance computing on tablet platforms		200.000	
JTI-CS-SGO-04	*Area-04 - Aircraft Demonstrators*		**1.450.000**	
JTI-CS-2013-3-SGO-04-006	Thermal Mock-ups for Thermal Management of a Ground Integration Test Rig		1.200.000	
JTI-CS-2013-3-SGO-04-010	Air Distribution assembly for EECS flight test demonstration		250.000	

Topic description

CfP Nbr	Title		
JTI-CS-2013-3-SGO-02-052	Electrical Starter / Generator disconnect system	**Start date**	T0
		End date	T0 + 18 Months

1. Background and context

New generation aircraft need high level of electrical power.

To answer this requirement, the electric generators increased in volume and thus their weight increased

To solve weight and volume this new high power electrical machines are designed be able to work in two modes:

Mode 1: starter to start the aircraft engine

Mode 2: generator to give electrical energy to the aircraft.

By this way, the current electrical generator of limited power and the pneumatic starter can be replaced by only one high power electrical starter-generator.

For safety reason, to protect the machines and engine gearbox, the starter-generator need to include a disconnect system.

Under the effect of an electrical pulse, this system has to allow to separate mechanically the gearbox from the starter-generator. The transmission of the mechanical energy is then no more possible. In mode 1, the starter cannot drive any more the gearbox. In mode 2 the gearbox cannot drive any more the electrical generator.

The purpose of this (CfP) is:

1) to explore innovative topologies and technologies of disconnect systems adapted for aircraft electrical generator using these high power machines as a starter and choose the best topology.

2) to develop, build and test the chosen disconnect system capable of operating (approximate figures to be confirmed in full specification):

-up to –55°C to 200°C

-within the speed range 0 to 28000 rpm

- between -400 to and 400 Nm

- at a weight around 2 kg max

- with very high reliability

- with resetability capability (system resetable with starter generator still installed on aircraft, at least 6 times)

- with testability on aircraft

- Durability >20 Years

- including manufacturing robustness, service life …& cost objective

In this approach of disconnect system, criteria of compactness, weight reduction and conformity with harsh aeronautic engine environment (i.e 10 g) will be also an important part of this study.

This CfP is a technological and industrial challenge which provides opportunity of competitiveness on this important improvement part of disconnect system dedicated for new high power starter-generator for more electrical aircraft for European partners of Cleansky.

2. Scope of work

This study of disconnect system shall include following technical parts and activities:

1) Specification review

2) Trade studies of innovative disconnect system technologies,

3) Definition of criteria for solutions analysis,

4) Comparative analysis and solution selection,

5) Description of final hardware design solution proposed. Verification and justification of compatibility of chosen solution with aeronautic environment,

6) Methodology and definition of verification tests,

7) Design of the solution,

Test conditions shall include parameters such as temperature, stress, fatigue, ageing.

3. Type of work

T The activities of this work shall be limited to 18 months period. A kick-off meeting, a progress meeting and final meeting will be scheduled with topic manager. This project is split into following tasks proposed for the applicant activities:

At T0:

Kick of meeting to start project. Review of technical specification and planning to be frozen.

Task 1: (T0+2M): Clause by clause and final specification version.

Task 2: (T0+5M): Report of trade study of innovative solutions explored with different technologies (concepts, schematics, working drawings)

Task 3: (T0+6M): Criteria definition for trade study analysis.

Task 4: (T0+9M): Preliminary design review of trade studies in accordance with specification. On the basis of the chosen criteria comparison of the different solutions. Solution selection.

Task 5: (T0+15M): Critical design review of technical proposal for disconnect system. Review of the justification report of hardware solution dimensioning, demonstrating the compatibility with mechanical, electrical, thermal and fluidic environment of the starter-generator and the aeronautical environments.

If necessary, numerical models can be tuned by specific tests on subassembly. Those tests will be carried out by the applicant.

Task 6: (T0+18M): Review of verification and validation tests procedure

Progress reports will be requested every two months.

Detailed definition of the test plan, with the aim of covering extensive combinations of electrical, mechanical (vibration, shocks,…), temperature, test parameters, definition of the acceptance criteria, will be a joint activity with Topic Manager.

4. Special skills, certification or equipment expected from the applicant

For this study, the applicant shall satisfy following minimum criteria:

- Company with a very opened and innovative spirit,
- Good background and experience in electro-mechanical design and advanced technologies operating in harsh aeronautic environment,
- Insurance shall be provided to manage this work in time without delay for study and development phases.
- Adequate equipment with tools, for thermal, electrical and mechanical simulations, manufacturing process and test benches to develop and test requested demonstrators in respect with milestone of delivery,
- Available resources to execute the respective tasks should be stated in the proposal.
- Laboratory for material tests (if not sub-contacted), in various environment conditions.
- Expertise on metallic, composite and plastic materials used at high temperature level
- Experience in aeronautics material tests, and qualification methodology.

5. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Requirements Analysis	Review and finalisation of module requirements specification (clause by clause) and SOW (statement of work)	T0+2M
D2	Report of trade study of potentials topologies suitable with the specification	Concepts of innovative solutions defined by schematics, working drawing, description Minimum of three potential solutions shall be proposed.	T0+5M
D3	Report of criteria definition	List of criteria to be used for solution choice	T0 + 6M
D4	Preliminary Design Review (PDR) of trade studies according the specification of the need and of the starter-generator environment	Analysis of benefits and drawbacks of potential solutions Technical description of concept structure, functionality and technologies of proposed solutions. Selection of solution.	PDR: T0+9M
D5	Critical Design Review of frozen solutions of disconnect system selected for hardware design and analysis	Design file, bill of material and technical documents necessary to justify solution dimensioning, demonstrating the compatibility with mechanical, electrical, thermal and fluidic environment of the starter-generator and the aeronautical environments. Design FMEA, Chain of dimensions. 3D models, 2D drawings	CDR T0+15M
D6	Delivery of tests plan and tests procedures	This document will define the list of tests to be applied, the tests sequence, the procedure to make these tests and the number of equipment to be summated to the tests.	T0+18M

6. Topic value

The total value of biddings for this work package shall not exceed

600.000 €
[six hundred thousand euro]

Please note that VAT is not applicable in the frame of the CleanSky program.

Clean Sky Joint Undertaking
SP1-JTI-CS-2013-03-SGO-02-066

Topic Description

CfP Topic Number	Title		
JTI-CS-2013-03-SGO-02-066	HVDC fuses design, development, validation and integration	**Start Date**	T0
		End Date	T0 + 24 Months

1. Background

Aeronautics power distribution systems are usually protected by active switching components, driven by electonics. In order to reduce response time and simplify protection driving, fuses are being considered for Cleansky HVDC network (540VDC). This study may lead to future aircraft projects.

2. Scope of work

The objective of this task is to develop, test, and deliver fuses adapted to high DC voltage networks to be integrated into aircraft EPDS (Electrical Power Distribution System).

3. Type of work

Tasks foreseen:

1. State of the art of existing aeronautics fuses
2. Module definition & realisation
3. Validation:
   - 3.1 Standalone module validation & testing
   - 3.2 engineering test according to DO160 standard
   - 3.3 TRL demonstration
4. integration & test into EPDS

The fuses shall be compliant with the following requirements (this list may be completed with the partner):

1- The fuse shall handle a 540VDC (+/-270VDC) nominal voltage, with 5 seconds peaks of 750VDC and unlimited overvoltage of 650VDC.

2- The fuse shall handle a 83A nominal current (at 51000ft) and be operationnal within the range [50A-200A].

3- The fuse shall handle lightning currents of 700A during 300µs.

4- The fuse melting time shall be lower than 3s at 300%*In, 10ms at 1000%*In (after fault condition declaration).

5- The fuse lifecycle shall be long enough to minimize maintenance operations.

6- The fuse maximum weight is 200g.

7- The fuse shall be as compact as possible.

8- The fuse shall be compliant with the aeronautic environment constraints, as detailed in DO160 standard (altitude, pressure, temperature, accelerations, vibrations, humidity,...)

9- The fuse shall pass the fire and explosion safety tests described within UL508C standard.

4. Special Skills, Certification or Equipment expected from the Applicant

Aerospace or industry fuses supplier familiar with:
- HVDC
- DO160 standard
- UL508C standard
- Aerospace electrical network environment

5. Major Deliverables and Schedule

Del. Ref. Nr.	Title	Description (if applicable)	Due
D1	Existing aeronautics fuses state of the art review		T0+3 Months
M1	PDR		T0+7 Months
M2	CDR (TRL3)		T0+12 Months
D2	Prototypes delivery		T0+14 Months
M3	Start prototypes testing (electric and environment)		T0+14 Months
D3	Test results analysis		T0+17 Months
M4	Conception correction and improvements identifications		T0+17 Months
D4	Updated prototypes delivery		T0+20 Months
M5	Start updated prototypes testing (electric and environment)		T0+20 Months
D5	Test results analysis		T0+23 Months
M6	Prototype delivery for EPDS (TRL5)		T0+23 Months
D6	Final report		T0+24 Months
M7	Technical support to integration & test of the fuses into EPDS		T0+24 Months

6. Topic value

The total value of biddings for this work package shall not exceed

800.000 €
[eight hundred thousand euro]

Please note that VAT is not applicable in the frame of the CleanSky program.

Topic Description

CfP Topic Number	Title		
JTI-CS-2013-03-SGO-02-083	**Adaptable power density coating for energy efficient heating of cockpit and cabin**	**Start Date**	T0
		End Date	T0 + 18 Months

1. Background

Today cockpit & cabin heating is mainly driven by engine bleed air pick up and mixing with outside air. The air is carried out to the cockpit & cabin through a complex pipe and valves system exhibiting an important loss of heating power. The air exhausts are located in the cockpit & cabin at few location and the warm up is achieved by air convection. Due to the high level of leakages on e.g. helicopters unpressurized cockpit & cabin, the heating power losses are important and the homogeneity of the heating confort quite poor. In addition, without engine running, on ground pre-heating of the cockpit & cabin cannot be achieved. Cold spots in aircraft cockpits and cabin in the vicinity of e.g. doors lead to a considerable discomfort.

2. Scope of work

The idea is to develop a heating coating that can be easily adapted to high 3D geometries and the power density of which can also be easily changed all along the 3D surface to be treated.

For cockpit & cabin heating, it should then be added to all surfaces except transparencies in a manner to provide a much better comfort feeling to the crew or the passengers by radiant heat reducing the need for bleed air exhaust. It could also allow some pre-heating of the cockpit and/or the cabin without running engines or APU on ground for nothing else.

In any case, its function should not be significantly degraded due to environmental aggression as listed in standards such as DO160, including lightning as well as other electromagnetic compatibilities and interferences aspects.

So the new coating shall be compatible (e.g. adhesion, ageing) with paintings, metallic and composite substrates currently in use within the aviation industry.

It shall be able to provide power density from 0 to 2W/cm2.

It shall be compatible with the electrical insulation materials glass fabrics, PEEK and PU.

All the previous material compatibilities shall be kept under the maximum temperature achieved by the coating, which shall be limited to max 60°C.

3. Type of work

The applicant shall provide:

- Aero-Thermal modelisation showing efficiency of the concept for a cockpit & cabin heating.
- Analyses and tests on coupon showing compatibilities with the differents substrates or cover layer material as above, insulation properties and thermal efficiency.
- Analyses and tests on coupon showing behaviour to external aggressions, such as described in DO160 as far as reasonable applicable, including EMC aspects.
- Detail design of the cockpit & cabin assemblies.
- Full scale cockpit mock-up equiped with thermal coating tested in a climatic chamber or wind tunnel to show efficiency of the radiant heating either in pre-heating mode or in-flight mode,
- Manufacturing process details and repair procedures, verification tools or processes for acceptance after any manufacturing or repair.

Note:

A mock-up can possibly be made available to the applicant upon request for the application of the coating and the subsequent test.

4. Special Skills, Certification or Equipment expected from the Applicant

The applicant shall be capable of using CFD and Thermal modelisation tools, capable of CATIA models.
The applicant shall be skilled in chemical composition (safety of products, compatibility), mechanical adhesion and thermal properties.
No certification skill required.

5. Major Deliverables and Schedule

Del. Ref. Nr.	Title	Description (if applicable)	Due
D01	Technical system design & description	Report to include material data sheets and material characteristics (thermal and mechanical coefficient, electrical characteristics)	T_0 + 4 month
D02	Thermal simulation report		T_0 + 8 month
D03	Test plan	(incl. measurement tool characteristics and calibration)	T_0 + 12 month
D04	Milestone: Mock-up ready for test		T_0 + 15 month
D05	Test report	(incl. measured raw data in numerical format); incl. report showing material compatibility	T_0 + 17 month
D06	Final TRL assessment report		T_0 + 18 month
D07	Final report		T_0 + 18 month

6. Topic value

The total value of biddings for this work package shall not exceed

1.000.000 €
[one million euro]

Please note that VAT is not applicable in the frame of the CleanSky program.

7. Remarks

All core RTD activities have to be performed by the organisation(s) submitting the proposal. If some subcontracting is included in the proposal, it can only concern external support services for assistance with minor tasks that do not represent per se project tasks.
The proposal must :

- indicate the tasks to be subcontracted ;
- duly justify the recourse to each subcontract ;
- provide an estimation of the costs for each subcontract.

(concerning subcontracting, see provisions of the Grant Agreement Annex II.7)

Objective: TRL 4 or higher

Topic Description

CfP Topic Number	Title		
JTI-CS-2013-03-SGO-02-084	**Optimizing power density of aircraft inverter by combining topology and PWM-patterns**	**Start Date**	T0
		End Date	T0 + 26 Months

1. Background

EMI is an important issue in the development of power electronics system. The mitigation of such phenomenon has a huge impact on the development time and costs and the design of aerospace products.

The current state of the art to ensure the EMC of the systems is the use of filtering. This necessary mean has an important impact on the total weight and volume of the systems.

The typical noise coming from drive system with power electronics converters is done through the intrinsic operation of such systems: the floating potentials at the output of the converter (3-phase output voltages) are building the common mode voltage which is the main source of interferences in the system: this voltage will create, through the different common mode impedances, common mode currents which are responsible of the common mode emissions. Also an important issue is to reduce these currents because there are flowing through the structure of the system and this could be critical when using carbon fibre structure. Furthermore, these common mode currents will create, via the output cable that acts as an antenna, radiation that could disturb the other systems in the environment of the e-drive.

Most of the today's solutions to decrease the emissions are to work on the path of this common mode currents i.e. using heavy passive or active filters. Another possibility is to work on the source i.e. on the common mode voltage via different solutions: control of the dv/dt of the semiconductor, dedicated PWM pattern or alternative topologies. These principals are known from PV-plants with the big panels, where ground currents are also a problem. Thus, optimization of common mode voltage allows reducing the filters.

2. Scope of work

The scope of the work will focus on two typical power ranges (10kW and 50kW)

A first part of the topic is dedicated to the study of innovative solution to optimize the common mode voltage for 3 phase drive applications. A bibliography on the state of the art also in other domains (like PV-inverter) will provide an overview of the potential solution for aerospace system. Additional studies via analysis and simulations will be performed on typical aerospace power electronics systems.

The second part of the project will focus on implementation and demonstrations of the selected solutions. The goal here is to achieve two power cores 10 kW and 50 kW with filters at TRL4 level. The demonstration has to proof, that the DO-requirements will be fulfilled and a weight gain over existing solutions can be achieved (target is to decrease up to 10% at power electronics system level). Also are to be highlighting the different performances trade-offs (for instance: decrease of the dv/dt will lead to increase of the semiconductor loss) using the considered technologies.

3. Type of work

1) Design study:

a) At first a theoretical analysis should be done for PWM patterns in conjunction with different topologies in order to optimize the common mode voltage.

b) The identified relevant solutions for the 10kW and 50kW applications should be sized and simulated

2) Hardware-Implementation:

a) A 10 kW power core with filter will be implemented in a relevant system

b) A 50 kW power core with filter will be implemented in a relevant system

c) EMC-measurement (conducted emissions regarding RTCA DO-160) will be performed in order to proof the concept

4. Special Skills, Certification or Equipment expected from the Applicant

The successful partner will have demonstrated expertise in industrial drive applications provides analytical capabilities in order to identify and model EMI in PE environment and is able to build the required hardware.

5. Major Deliverables and Schedule

Del. Ref. Nr.	Title	Description (if applicable)	Due
D1	Report: Theoretical analysis		T0 + 6 Months
D2	Report: Simulations of the selected solutions		T0 + 9 Months
D3	HW: 10 kW power core + filter TRL 4 implementation		T0 + 20 Months
D4	HW: 10 kW power core + filter TRL 4 implementation		T0 + 20 Months
D5	EMC measurements of 10 and 50 kW power cores		T0 + 26 Months
D6	Final test report		T0 + 26 Months

6. Topic value

The total value of biddings for this work package shall not exceed

500.000 €
[five hundred thousand euro]

Please note that VAT is not applicable in the frame of the CleanSky program.

Topic Description

CfP Topic Number	Title		
JTI-CS-2013-03-SGO-02-085	**Development of a composite sleeve for spatial separation of rotor and stator in an electric motor**	**Start Date**	T0
		End Date	T0 + 18 Months

1. Background

In some electrical aircraft actuation systems the motor is flushed by a fluid. The advantage is for example a better heat transmission from the rotor.

These fluids are partly very aggressive and so they have to be separated from the potted stator.

Currently this separation is a complex construction from metal and plastic because at some special failure cases the fluid pressure can be very high.

An innovative approach could be to realize this separation with a composite sleeve which can resist the pressure and the heat and shows a good chemical stability.

With this the production effort and the production risk of the stator can be clearly reduced.

The aim of this call is to find out the right materials and techniques for manufacturing a slim composite sleeve which is compliant with the requirements concerning pressure, temperature and chemical stability.

The second topic is to test the resulting sleeve. Firstly, alone against the requirements and secondly, in a corresponding motor prototype to see the behaviour under operational, environmental and failure conditions.

2. Scope of work

- To develop a heat and pressure resistant composite sleeve with high chemical stability and small wall thickness.
- The following main requirements shall be considered:
    - Material shall be able to resist a temperature > 200°
    - Material shall be non-conductive
    - Composite sleeve shall be able to resist a pressure of 350 bar
    - Wall thickness shall be not more than 2.5mm

Because of the build in situation at the motor there are a lot of supporting points around the contour of the sleeve which are able to absorb the pressure force.

The applicant shall be able to manufacture and test prototypes of the composite sleeve (pressure, heat, chemical)

It is necessary to optimize the construction and technique of the sleeve for industrial manufacturing and to analyse the costs for serial production.

3. Type of work

The applicant will be responsible for:

- the selection of the materials for the composite sleeve (resin, fibre, …)
- the development of a manufacturing process for the sleeve

- to build prototypes for stand-alone tests
- to perform test concerning the requirements (temp., pressure, chemical), fatigue and endurance
- to optimize materials and manufacturing process concerning quality and cost
- a cost analysis (RC / NRC) concerning serial production

4. Special Skills, Certification or Equipment expected from the Applicant

The applicant should have:

- extensive experience on composite material and technique
- tools for calculation and simulation (FEM) for composite material
- equipment for testing composite material (pressure, heat, chemical)
- experience in industrial manufacturing

5. Major Deliverables and Schedule

Del. Ref. Nr.	Title	Description (if applicable)	Due
D1	Development of a separation sleeve for E-Motors	Report: stress calculation, simulation results, material, manufacturing process	T0 + 6 Months
D2	Prototypes composite sleeve	10 prototypes of the separation sleeve	T0 + 12 Months
D3	Test report composite sleeve	Report: Results of the stand-alone tests of the sleeve concerning requirements	T0 + 15 Months
D4	Methods of industrial production	Report: Procedures for the industrial production of the composite sleeve optimized concerning cost and quality, listing of critical processes, needed equipment	T0 + 18 Months

6. Topic value

The total value of biddings for this work package shall not exceed

300.000 €
[three hundred thousand euro]

Please note that VAT is not applicable in the frame of the CleanSky program.

Topic Description

CfP Topic Number	Title		
JTI-CS-2013-03-SGO-02-086	**Development of actuator components made by alternative metal injection moulding (MIM) process**	**Start Date**	T0
		End Date	T0 + 18 Months

1. Background

Nowadays most small and complex metallic parts are made by traditional and cost intensive manufacturing by means of milling and turning. Furthermore complex design shapes are manufacture by different parts assembly's which means big amount of chipping of not used material. These factors increase the costs and environmental impact on the parts and used manufacturing energy of small and complex metallic parts. The alternative manufacturing of these parts by means of MIM (Metal Injection Moulding) can reduce costs and energy and allow a higher complexity in one manufacturing step.

Metal Injection Moulding means a near net shape design by injection of metallic powder in a mould (similar to plastic injection) and with nearly the same material strength as components made by metallic bars by milling and turning. This process is well established for manufacturing in different industries but not in the aerospace industry especially for components in the primary and secondary flight control (actuators).

The goal of this topic is to develop parts for the primary and secondary flight control e.g. used in actuators by means of the MIM process which are able to withstand the high strength and quality requirements which are necessary for aircraft applications. These parts should be less cost intensive as the traditional used ones. Furthermore the quality of the feedstock, manufacturing process and sufficient material values shall be approved during the project by means of material and part tests in a relevant adaption and environment.

The applicant shall investigate possible metallic parts used in aircraft application for their potential to manufacture them by means of the MIM process in order to reduce costs and manufacturing time and material scrap. Furthermore the proof of sufficient material strength values and quality of the process should be assured by the applicant.

Additionally after successfully manufacturing of material specimens and first prototypes the strength and fatigue of these parts should be proofed by adequate tests.

This call for proposal is a scientific and industrial challenge provides opportunity of competitiveness on improvement of costs and manufacturing of parts used in e.g actuators for flight control for European partners of Clean Sky.

2. Scope of work

This study and work on the development of parts made by metal injection moulding shall include following technical parts and activities:

a. State of the art study for materials which can be used by means of feedstock for the metal injection moulding

b. Select one possible material and proof their material strength values for the application and substitution of traditional metallic bar materials used in aircraft applications

c. Screen flight control parts for their ability to substitute them by parts made of MIM process

d. Select one or two parts or more (depending on part complexity) and manufacture a minimum quantity of about 30 pieces of one part by means of MIM and proof their quality for later aircraft applications

e. In order to investigate the quality of the material and manufacturing process of the above mentioned MIM parts they should be manufactured from a minimum of two different feedstock batches

f. Conduct a cost and manufacturing study and compare them to standard part manufacturing

g. Conduct tests on specimens and prototypes for the evidence of sufficient strength and quality values for a later application on aircraft parts

The minimum expected feedback of this work for technical part is:

- Feasibility study of the MIM process for small aircraft metallic sub parts
- Quality study of the used material and process for aircraft application
- Realistic strength values for design and calculation
- Better knowledge of the process and design criteria
- Manufacturing of specimens and prototypes
- Tests on specimens and prototypes
- Tests results and comparison to traditional metallic parts and material values
- Prospective view for industrialization and cost reduction possibilities of parts made by metal injection moulding

3. Type of work

The activities of this work shall be limited to 18 months' time period. A kick-off meeting, progress meetings and a final meeting will be scheduled with topic manager. This project is split into following tasks proposed for the applicant activities:

- **At T0** (assumed in beginning of June 2014) Kick of Meeting to start project. Review of possible actuation parts, requirements and specification and planning to be frozen
- **Task 1 (T0+2M)** Identification of possible metallic parts on aircraft actuators and components of flight control systems
- **Task 2 (T0+4M)** Summary of requirements on identified parts (Material and Part Specification) / Selection of planed used MIM Material / Display of possible Material values of selected MIM Material / Review with Topic Manager
- **Task 3 (T0+8M)** Adequate MIM Design of selected Parts / First calculation of parts according to standard MIM material values / Cost Analysis of MIM Parts and comparison to standard parts / Identification of the benefit / Review with Topic Manager and Release CDR to start prototype manufacturing
- **Task 4 (T0+12M)** Detailed calculation and manufacturing of prototypes and material specimens of used MIM Material / Measuring and Quality investigation of prototypes and material specimens
- **Task 5 (T0+16M)** Test of specimens (Tension / Fatigue etc.) and comparison of results to standard material data sheets / Tests of identified Prototypes in regard to strength and fatigue and recalculation according to reached material values (Review of results with topic manager)
- **Task 6 (T0+18M)** Summary of all results developed in the project / Delivery of completed test report / Display of reached TRL Level and Benefit / Complete final project report and final meeting with topic manager

4. Special Skills, Certification or Equipment expected from the Applicant

For this study, the applicant shall satisfy following minimum criteria:

- Good background and experience in manufacturing of parts made by metal injection molding
- Good background and experience in material knowledge of feedstock and process quality of MIM parts
- Insurance shall be provided to manage this work in time without delay for study and development phases.
- Adequate equipment with tools, injection molding machines and quality control
- Available resources to execute the respective tasks should be stated in the proposal.

5. Major Deliverables and Schedule

Del. Ref. Nr.	Title	Description (if applicable)	Due
D1	Feasibility study	Summary of identified substitutional MIM Parts (Report)	Task 1 (T0+2M)
D2	Selection of MIM Material and requirements of MIM	Requirement Analysis / Planned Material and values accord. to data sheets (Report)	Task 2 (T0+4M)

	Parts		
D3.1	Design and Cost Analysis	MIM design of selected parts (CAD) file / First calculation report / first benefit report regarding costs and comparison	Task 3 (T0+8M)
D3.2	CDR (pre development)	CDR presentation to start with manufacturing of specimens and selected parts	Task 3 (T0+8M)
D4	Prototypes and Specimens	Prototypes / Quality investigation report including also micrographs	Task 4 (T0+12M)
D5	Test Results	Test Results of Prototypes and Material values in regard to strength and fatigue, beam impact test (Test report)	Task 5 (T0+16M)
D6	Project Closure	Summary and Final report of results and comparisons and forecast	Task 6 (T0+18M)

6. Topic value

The total value of biddings for this work package shall not exceed

200.000 €
[two hundred thousand euro]

Please note that VAT is not applicable in the frame of the CleanSky program.

Topic Description

CfP Topic Number	Title		
JTI-CS-2013-03-SGO-02-087	**Technology development and fabrication of high-temperature high-frequency capacitors for power switch integration**	**Start Date**	T0
		End Date	T0 + 24 Months

1. Background

Improvements in the power density, efficiency and reliability of solid-state power modules (active switches in power electronics converters) have not been matched by the progress in the area of passives (capacitors and inductors), which are however key parts of a power conversion system.

In particular, major advancements in designing high performance lightweight and small volume power systems for avionic applications would be drawn by the availability of high temperature capacitors (at least 150 ºC steady-state, with a view at achieving 200 ºC over the project duration) suitable for high frequency filtering and for embedment within solid-state power modules. This Call for Proposal will support other on-going activities targeting the demonstration of very compact converters by supporting the development of high performance high temperature ceramic (or equivalent performance) capacitors.

The bidding Consortium should include at least an industrial manufacturer who can guarantee the commercialisation of developed solutions. As part of this Call, the successful applicant will interact very closely with the Topic Manager to develop optimum solutions, not only in terms of the component performance, but also of its size and finishing for integration within a power module.

2. Scope of work

1. **Introduction**: Define state-of-the-art and realistic roadmap for HT HF capacitors with suitable characteristics for the design and development of highly integrated lightweight airborne power converters.
2. **Samples and qualified product development**: Deliver, in subsequent steps, at least two capacitor types (e.g., different voltage ratings and capacitance value, sizes) suitable for HT HF operation under representative working conditions. Component specifications and quantity will be defined in detail with the TM during the negotiation phase. However, the minimum expectation is:
   - 50 qualified components with capacitance at least 220nF and voltage rating at least 600 V;
   - 50 components with capacitance at least 4.7uF and voltage rating at least 250V.

All parts will be specified up to at least 150C with 200C target (X8R and X9R capacitor specifications).

Reliability will be tested at upper rated temperature and rated voltage, with at least a 1000 hour test.

3. **Design**: Contribute expert knowledge to the integrated design of power switches with capacitor embedment
4. **Reporting**: Test reports for qualified products are a desired deliverable

3. Type of work

Samples and qualified component production. Support of integrated switch design and testing.

4. Special Skills, Certification or Equipment expected from the Applicant

The successful partner will have demonstrated expertise in technology development and manufacturing capability of high temperature capacitors suitable for filtering of high frequency current components with a performance comparable to that of ceramic components at least. They will be independent in manufacturing and/or sourcing the required test samples and components; the partner will have access to latest technology and fabrication capability. Experience in the application of electrical, thermal and mechanical co-design is essential as is the knowledge and capability of carrying out technology qualification tests in conformity with avionic specifications.

The partner will have experience and be certified for the industrial development of capacitors and be to some extent confident with innovative interconnect, packaging and cooling solutions. The partner will include at least a capacitor manufacturer of proven experience, equipped and resourced to provide the type and number of components required for programme evaluation. Finally, the partner will be able to demonstrate an established track record in working with industry and academia on new power technologies.

5. Major Deliverables and Schedule

Del. Ref. Nr.	Title	Description (if applicable)	Due
D1	Technology review report	Assessment of state-of-the-art in the area of HT HF capacitors	T0 + 2 Months
D2	Technology roadmap report	Agree with TM the development of components with characteristics of interest for the development of integrated lightweight avionic applications	T0 + 3 Months
D3	First test sample	First batch of sample capacitors delivered to TM for integration exercise	T0 + 9 Months
D4	Second test samples	Second batch of sample capacitors delivered to TM for integration exercise	T0 + 12 Months
D5	First reliability/lifetime qualified components and qualification report	First batch of qualified components delivered to TM for integration exercise at higher TRL (at least 5 is aimed at)	T0 + 16 Months
D6	Second reliability/lifetime qualified components and qualification report	Second batch of qualified components delivered to TM for integration exercise at higher TRL (at least 5 is aimed at)	T0 + 20 Months

6. Topic value

The total value of biddings for this work package shall not exceed

440.000 €
[four hundred forty thousand euro]

Please note that VAT is not applicable in the frame of the CleanSky program.

Topic Description

CfP Topic Number	Title		
JTI-CS-2013-03-SGO-02-088	**Accelerated Life Testing of Electrical Motor Drives**	**Start Date**	T0
		End Date	T0 + 20 Months

1. Background

Electrical machines and drives being developed within the CleanSky programme are adopting novel, power-dense, circuit and electromagnetic topologies working close to the material limits and excited by non-conventional waveforms. Critical in moving these devices to higher TRL levels is the correct understanding of potential failure mechanisms and failure rates and design and manufacture methodologies for higher reliability. Algorithms to monitor drive usage and remaining lifetime are also critical in moving to a higher TRL level.

It is known that various factors can have a significant effect on the electrical drive lifetime including device voltage rise time, the machine's high frequency impedance, magnet wire insulation, insulation between phases, insulation to ground, slot fill, varnish compound, thermal gradients, coil layout, etc. In addition to these aspects, manufacturing aspects/quality also have an impact on the drive lifetime including lamination manufacturing quality, end winding support, improper slot insertions, incomplete curing of varnish, voids, poor connections, etc. Correct understanding of the degradation mechanisms will allow for improved drive design and improved drive system reliability. This can have significant effects on drive redundancy and eventual system weight.

This project is expected to inform drive designers and engineers on design methodologies and manufacturing technologies for enhanced reliability, provide for more realistic reliability data for such drives and help the development of usage algorithms and remaining lifetime estimation.

The purpose of this CFP is to develop a test setup able to investigate accelerated deterioration of electrical drive systems for aerospace application. The work will replicate realistic environmental conditions and supply waveforms to enable accelerated deterioration as well as instrumentation to enable usage models of the drives. This CFP will help the European aeronautic partners to have better life consumption models, develop improved diagnostic techniques and improve reliability by reducing the amount of rotational sensors.

2. Scope of work

The aim of this CFP is to find a partner who has the necessary experience and capabilities to develop a high performance setup able to achieve loading and environmental conditions suitable for accelerated lifetime degradation of electrical drives and suitable data acquisition to inform on degradation models.

In summary the flexible test setup delivered to the institution of the topic manager will be expected to fulfill the following requirements to ensure accelerated lifetime testing of the aerospace drives:

- Digitized measurement setup which can give reliable and repeatable results
- Flexible setup able to measure different physical parameters including vibration/speed/temperature
- Be capable of loading the electrical drive to the desired power-speed ratings
- Be capable of supplying the motor under test with regulated power device switching profiles
- Be capable of a regulated temperature and pressure environment.
- Be supplied with the relevant software for data acquisition and post-processing

The dynamometer shall have a nominal mechanical rating of 40kW at 20krpm. It is to provide a test environment at various temperatures and pressures within an environmentally controlled test chamber. A test temperature range of -40 to +300°C and a pressure range equivalent to altitudes from sea level to 50,000' are envisaged. The associated heater system, chiller and vacuum pump system will be required. Also, the chamber will need to accommodate the test article(s) plus other items which may include heat exchangers, fans, evaporator equipment etc. Other requirements will be entry for power cable and instrumentation for the unit under test. Access to mount test units will be required plus other features which may include visual inspection panel(s), camera access etc.

It is envisaged that a suitable data acquisition and control system would be developed. This would interface with the load drive to enable testing to be carried out in a controlled and programmable manner with relevant test data acquired, stored and presented. This control system will also interface with both the test chamber temperature system and the vacuum arrangement for control of test temperature and simulated altitude level. The test system would also incorporate a wide range of monitoring and safely systems to ensure the security of personnel and equipment during operation.

3. Type of work

The expected type of work will be mainly based around experimental development of the accelerated lifetime test bench targeted towards determining electrical drive components degradation and the development of usage algorithms. Associated sensor interfaces, data acquisition and algorithms will need to be developed and implemented.

4. Special Skills, Certification or Equipment expected from the Applicant

The chosen partner/consortium must exhibit demonstrable experience in the development of electronic/test bench hardware. It is essential that the applicant has a proven track record of research and development in this area.

5. Major Deliverables and Schedule

Del. Ref. Nr.	Title	Description (if applicable)	Due
D1	Review report on failure mechanisms in electrical motor drives and accelerated lifetime testing methods.	Review of failure mechanisms in electrical drives and methods to accelerate life consumptions for effective lifetime evaluation.	T0 +1 Month
D2	Review report on diagnostic/prognostic indices indicative of life consumption.	Review of diagnostics and usage algorithms in electrical drives and their respective requirements in terms of sensors and measurements.	T0 +4 Months
D3	Preliminary design review of accelerated lifetime test seup	Proposed methodology, including electrical loading drive (motor and convertor) selection, of environment conditioning and cycling, sensor selection and methods to be used to measure the required parameters.	T0 +6 Months
D4	Critical design review	Design review of test setup and detail of expected results.	T0 +8 Months
D5	Delivery, installation and commissioning of test setup	A demonstration of capability of the setup to monitor the agreed upon measurands has to be presented.	T0 +14 Months
D6D5	Performance review	Report on the performance of the test setup in assessing the life consumption of different electrical drive components.	T0 +20 Months

6. Topic value

The total value of biddings for this work package shall not exceed **800.000 €** **[eight hundred thousand euro]** *Please note that VAT is not applicable in the frame of the CleanSky program.*

Topic Description

CfP Topic Number	Title		
JTI-CS-2013-03-SGO-03-027	**Provision of a cross platform development tool suite for high performance computing on tablet platforms.**	**Start Date**	T0
		End Date	T0 + 18 Months

1. Background

The Clean Sky project, Systems for Green Operations ITD, is looking for a supplier a cross platform development tool suite for C/C++/Ada95-83/Fortran77-90 for high performance computing on tablet platforms.

Joint ventures with legal personality and liability can also respond to this topic Call for Proposal.

Introduction: Clean Sky SGO MTM project objectives and context of the topic

The System for Green Operations research consortium of Clean Sky aims to demonstrate substantial reductions of environmental impacts in civil commercial mainline, regional aircraft and business jet domains.

The Management of Trajectory and Mission (MTM) branch of the Systems for Green Operations research consortium aims at developing technologies to reduce chemical emissions (CO2 and NOx) and Noise. One of the main field of research considered by MTM to reach these objectives is to optimize in-flight 4D trajectories, including the overall missions profiles, through mathematical optimisation.

This mathematical optimisation uses computationally intensive agorithms written in standard compiled languages (C(99), C++(ISO), Fortran 90, Ada)

Given the nature of some of the algorithms, they are bound to be implemented on EFB platform. The development of tablet computing with multi-core CPUs make this kind of platform more and more likely to become the standard for EFB.

Nevertheless most of these platform are either constrained to software development kits that limit the portability of high performance scientific software (Java APIs, Objective-C/C++, no support for Fortran or Ada…)

While the open source software (through the GNU compiler chain and the LLVM infrastructure with dragon egg backend) exists that would allow development of compiler suites needed for development of optimisation codes on tablet computers, the additional development work to bring theses suites to production level should not be underestimated.

This CfP intends to provide the partners of Clean Sky with a usable development suite that allows source portability of optimisation software on all major platform and OSes for portable computing.

Context of use

The development suite will be used primarily on desktop computers for cross compilation of codes to be deployed on tablet computers.

Three development platforms and three deployement targets are considered

The development platforms are :

-Windows XP/seven 32 bits editions

-Windows seven 64 bits edition

-Mac OS X running on 64-bits intel architecture

The target platforms are

-IOS running on ARM architecture

-Android running on ARM architecture

-Windows 8 running on Intel-compatible architecture

The development suite must have the following tools:

-Cross compilers for C(99)/C++(ISO 98/03)/Ada95-83/Fortran 77-90,

-pre-processor(s),

- linker,

- make utility (compatible with GNU make format),

-assembler,

-cross debugger.

-standard libraries (standard C, standard Ada,standard C++, C++ STL, pthreads or C11 threads, BSD sockets)

-A memory debugger is highly desirable (e.g electic fence, valgrind …)

Inasmuch as possible it should integrate with existing Integrated Development Environments (IDE). For IOS that implies some integration with Xcode or Apple command line tools, for Android Eclipse integration is desirable, for windows 8, Eclipse is favored but MS Visual studio is a possible alternate.

For systems providing native emulators (e.g. IOS emulator on Mac), consideration should be given for native compilation suite for this emulator (even though this is not a requirement).

The suite is expected to have a development/maintenance life exceeding the span of Clean Sky since new platform/OS combination may arise in the future (e.g. Android on Intel platforms, evolutions of ARM architecture, release of limitations on such and such OS, use of GPUs to off-load CPUs …). It also can find a use anywhere scientific computing can be needed in a portable computing device.

The respondent can thus spearhead an innovative domain in technology. A clear industrial roadmap from the respondent, spanning new applications, may be of interest in this context.

2. Scope of work

Description of work

The end-result of this call is the provision of a innovative cross platform development tool suite for high performance computation on tablet computers.

The activity will be carried out along the 18 months of the project. The validation will consist on the porting of various optimisation software source codes to :

-IOS on ARM

-Android on ARM

-Windows 8 on Intel

The first work to be accomplished will be analysis of publicly available (commercial or not) development suites for each of the corresponding platform. This analysis should give an overview of what are the gaps between the off-the-shelf solutions and the level of service required in the call. It is expected that the proposal will include already a first version of this analysis.

The second work will be to propose solutions to provide this service. It can be achieved either through integration/adaptation of existing software packages or dedicated development.

After the downselection of a solution, the applicant will peform all usual development/integration/validation/delivery activity of the software package.

A deployement phase at the premises of one to three SGO members should be taken into account in the proposal, including installation, assistance to the tests of the suite and training of a selected panel of users (training may be centralised at the applicant premises).

The cycle should be performed at least twice during the project to ensure that proper user feedback can be taken into account for Clean Sky applications.

3. Type of work

Development/adaptation of a cross platform development tool suite for C/C++/Ada95-83/Fortran77-90 for high performance computing on tablet platforms.

4. Special Skills, Certification or Equipment expected from the Applicant

The candidate organization shall have recognized in the development/adaptation of compiler technology
The applicant shall have demonstrated knowledge of cross platform developpment tool suites.
The applicant shall have experience in the development of high performance compilers (in the sense of the efficiency of the genrated code). This can be demonstrated through the exhibition of comparative becnhmark with mainstream compiler suites.

5. Major Deliverables and Schedule

Del. Ref. Nr.	Title	Description (if applicable)	Due
D1	Analysis of existing development kits	A textual description of the existing tool suites, their lack against the needs expressed for the call	T0+2 Months
D2	Proposal for the development suite	A textual description of the development strategy, with regard of reuse/development/adaptation of the tools in the suite	T0+3 Months
D3	First version of the suite	First version of the development suite with a draft of the final documentation as well as the test report and	T0+9 Months
D4	Final version of the suite	Final version of the development suite with the final documentation.	T0+16 Months

6. Topic value

The total value of biddings for this work package shall not exceed

200.000 €
[two hundred thousand euro]

Please note that VAT is not applicable in the frame of the CleanSky program.

7. Remarks

Reporting
Periodic progress reports – typically monthly - will be established including the following elements:
- Description of activities performed
- Specification, design and development steps achieved
- Tests results technical reports
- Status of the next deliverables and review milestones
- Updated planning
- Action items

Meeting and review policy
- Management & progress meetings shall be periodically planned during all the project to evaluate activities progress, agree on requirements and results assessments, prepare milestones and reviews, and deal with project management issues.
- Technical meetings shall take place on SGO Topic' s manager request, in order to discuss in details specific technical points
- Review meetings shall materialize the major steps and to state if all the works and documents foreseen for these review have been performed and are acceptable. Each deliverable shall be accepted by a review meeting

Proposal content
Amongst others, the proposal should include a first analysis of off-the-shelf solutions and what are the gaps between the off-the-shelf solutions and the level of service required in the call.

Topic Description

CfP Topic Number	Title		
JTI-CS-2013-03-SGO-04-006	**Thermal and electrical Mock-ups for Thermal Management of a Ground Integration Test Rig**	**Start Date**	T0
		End Date	T0 + 13 Months

1. Background

In the framework of JTI/Clean Sky, Systems for Green Operations (SGO), thermal ground tests are planned to be conducted in a new test facility located in Hamburg/Germany as part of WP4.2.2. This test rig will feature electrically powered air systems architectures and one main aim is to demonstrate thermal management for these architectures. It will be used to test Thermal Management architectures and functions in a representative environment, aiming at combining and optimizing all heat sinks and sources at aircraft level.

Thus the aim is to create a test set up that provides a most representative environment regarding the thermal behaviour of all equipment which are cooled or temperature controlled by the Air and Thermal Management Systems. Beside the Environmental Control System (ECS) and dedicated heat sinks, most electrical aircraft systems are involved in thermal management systems.

Not all electrical consumers and thus not all heat sources will be available as part of the tested systems. Therefore all other relevant equipment, which will not be physically represented in the test rig, will have to be physically simulated to achieve the correct load profile to the power electronics and therefore the thermal behaviour for the cooling loop.

The scope of the mentioned test rig is (from the final thermal consumers upstream to the electrical loads and their cooling):

- The thermal loads creating a representative environment for the electrically driven ECS (consisting of an air cycle pack and a vapour cycle system (VaCS))
- The pack and the VaCS themselves, including the electrical drives
- The power electronics to drive those systems
- Additional power electronics to complement the power electronics centre in order to create a representative thermal load for the cooling system
- Liquid and air cooling system including their ultimate heat sinks

The test rig will not include:

- the full set of real electrical consumers such as electrical main engine start or commercial loads,
- the electrical distribution network.

The whole electrical network will be tested on another test rig in WP4.2.1. This thermal test bench is fully representative for the thermal system and represents the electrical system only to the extent that is necessary to setup the relevant environment for the thermal system. In that global setup both rigs together become fully complementary to each other and cover the full scope of electrical and thermal system.

In order to establish the representative environment for the thermal test facilities, there are necessary electrical loads that complement the existing loads given by the pack and the VaCS.

The applicant shall develop the equipment necessary to enable an electro-thermal simulation dependent on the various electrical network applications. The components to be developed and manufactured by the applicant shall simulate electrical power off-take in real-time (soft real-time requirement) and thus heat generation on demand in accordance to the flight phases to be defined. For some equipment, the electrical load needs to be simulated as well. As these loads can reach up to 150 kW in total, it is planned to feed the electrical energy back to the test building electrical network.

2. Scope of work

A set of electrical equipment shall be developed and built that is able to supply various loads and simultaneously simulate the equivalent electrical switching losses depending on load behaviour (at various frequencies) with defined and programmable load profiles. The devices shall offer the possibility to simulate/control the thermal behaviour of these switching losses and connect various cooling systems that feature quick disconnects. Cooling system baseline should be liquid, with provision for air-cooled operation. The loads shall be programmable and the converted energy shall be fed into the electrical network of the building (400VAC, 3-phase).

The scope of the work under this call consists of three packages:

1. Design and build a power distribution centre, using currently available commercial equipment capable of driving various loads with 28VDC, 115VAC, 230VAC (TBC) and ±270VDC voltage inputs. Output switching and circuit protection is to be considered, as well as indication.

Internal power quality and current flows are to be recorded in real time with a level of precision which allows exact duplication of the load power demand.

2. A liquid cooled heat load is to be designed and built to simulate heat losses produced by solid state power conditioning inverters within an A/C power centre. The heat loads shall either use the real time parameters directly from the power distribution centre in 1. Above, stored data or imported data to simulate the switching losses in such an A/C power centre.The load bench is to be laid out in such a way as to allow multiple advanced semiconductor technologies to be simulated (SiC, GaN). To allow detailed investigation into load-cooling interaction the load bench must be reconfigurable to produce user specified redundancy switching scenarios, overload conditions, cooling loop loss/degradation. Provision should also be made to cool the heat loads only with forced air.

3. A set of programmable current sinks are required to simulate 115V/230VAC and +/- 270HVDC equipment under test which is not available until later in the project e.g. ECS pack and VaCS. Additional loads which will not be implemented physically into the test setup must also be simulated, such as main engine starter, fuel pumps, commercial loads, etc.

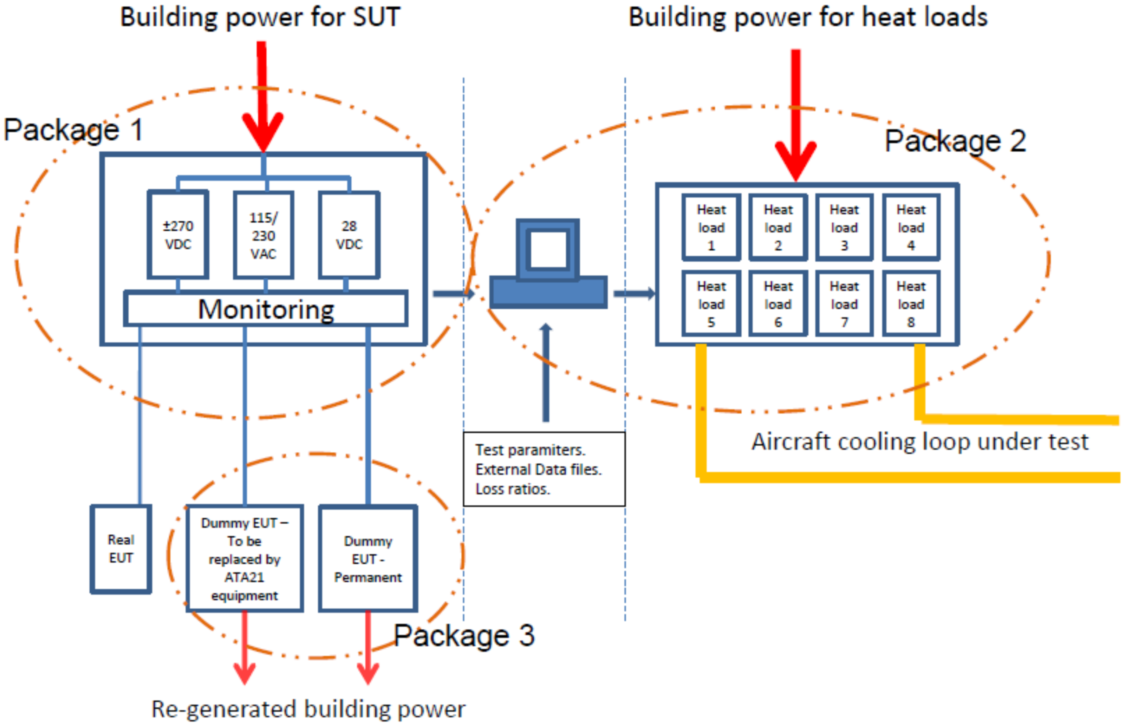
The AC loads should work with variable voltage and frequency inputs and be capable of absorbing 30 to 90kW of power. The DC load capability of one simulated consumer shall range from 10 to 70 kW. A total load of 150kW is needed to simulate the entire architecture.

Load sharing should be possible in order to cover various load levels, i.e. several modules shall be able to be coupled to act as one load to the power electronics centre. (Number of loads, load distribution and load sharing between modules will only be known once testing has started.)

All loads must be capable of either following a real time load profile from the test rig, a pre-recorded load profile or imported profile from third parties.

As a baseline, the absorbed current should be returned to the building power grid.

The following picture provides an overview of the different parts to be built (SUT = System under test, EUT = equipment under test, ATA21 = Air conditioning):



The three packages shall – together with the existing deliverables from outside this call – supply a full set of loads for the electrical power centre in the test rig. Close coupling of the power centre and the liquid/air cooled proportional heat load will allow investigation into, and demonstration of, the associated thermal management system, consisting of the liquid cooling system and/or the forced air cooling system for the non-liquid cooled parts of the power centre.

3. Type of work

The devices described above shall be developed manufactured and integrated into the test rig. The core part of these devices will be the programmable power electronic components for controllable heat dissipation. A challenge will be to enable to transform the variety of frequencies (and electrical voltage levels) to the building network values.

4. Special Skills, Certification or Equipment expected from the Applicant

Special skills in power electronics and power electronics cooling are required.
Experience in the design and build up of test environments is required.

5. Major Deliverables and Schedule

Del. Ref. Nr.	Title	Description (if applicable)	Due
D1	Acceptance and contribution to the specification		T0+ 2 months
D2	Architectural Design		T0+ 4.5 months
D3	Detailed Design and Build		T0+ 9 months
D4	Equipment delivery		T0+ 12 months
D5	Commissioning		T0+ 13 months

6. Topic value

The total value of biddings for this work package shall not exceed **1.200.000 €** **[one million two hundred thousand euro]** *Please note that VAT is not applicable in the frame of the CleanSky program.*

Topic Description

CfP Topic Number	Title		
JTI-CS-2013-03-SGO-04-010	**Air Distribution Assembly for eECS flight test demonstration**	**Start Date**	T0
		End Date	T0 + 16 Months

1. Background

In the framework of JTI/Clean Sky, Systems for Green Operations (SGO), flight tests are planned to be conducted on board the so-called electrical Flight Test Demonstrator (eFTD). The eFTD will feature electrically powered air systems (eECS; electrical Environment Control Systems) and one main aim is to demonstrate aircraft integration of such a system. It will be used to test integration and operation of an eECS system in a representative environment, in particular to reach actual flight conditions over the full flight envelope.

Thus the aim is to develop an eECS integrated into the eFTD that provides the most representative system architecture to be tested in real conditions. Beside the Environmental Control System (ECS) and dedicated Power Electronics, the fresh air inlets and outlets for the eECS requires special attention to ensure proper operation of the system and integration in the aircraft.

The scope of the mentioned eFTD will therefore include:

- A fresh air intake
- An Air Distribution Assembly inlet (ADA-i) distributing the fresh air to the electrical pack components
- The electric pack itself including electrical compressor
- An ADA connection (ADA-c) between electrical pack and existing aircraft valve interface.
- An ADA outlet (ADA-o) discharging the pack outflow into the pressurized fuselage.
- The power electronics to drive those systems
- The controller to control those systems
- An alternative ADA bypass (ADA-b) to enable specific hazard protection tests

In order to fulfil the mission, the ADA components in particular shall fulfil mechanical and thermal requirements to withstand normal operating conditions of a jetliner with internal flows, pressure differentials and in particular a tight tolerance regarding 3D geometry to enable clean flow distribution with minimal distortion, essential for the ADA-i part in particular. The aerodynamic study itself is out-of-scope but its results induce the definition of the 3D geometry which the ADA parts must comply to. Most ADA parts are in Fuel Vapor zones and overlap at least two aircraft sections so they must accordingly fulfil the related fuel hazard requirements & pressure tightness requirements at interfaces between compartments.

2. Scope of work

Two sets of all four ADA units shall be developed, built and qualified to be flight-worthy for flight test conditions, i.e. for few cycles and a short total operating time as opposed to in-service operation. The units shall be ready to install on the aircraft and comply with the specified 3D geometry for internal flows.

The scope of the work under this call consists of FOUR packages:

1. Design the ADA units to be flight-worthy for Flight Test conditions, to respect the internal aerodynamic shape critical for correct eECS operation. On top of installation tolerances and structural sizing case covering the dynamic and landing manoeuvers and sizing vibration levels, the units should also withstand internal flows of 0.7kg/s, speeds up to Mach 0.8 and static pressure deltas of up to 1 bar. Sections will have an equivalent diameter of up to 15cm. Here are some key dimension orders of magnitude for each of the units:

Unit	Nr of inlet interfaces	Nr of outlet interfaces	Approximate max dims of the containing parallelepiped	Nr of expected compartment crossings	Approximate Nr of installation rod attachment points
ADA-inlet	1	4	500mmx500mmx1000mm	5	4
ADA-connection	1	1	500mmx500mmx150mm	1	2
ADA-outlet	1	1	500mmx500mmx3000mm	2	10
ADA-bypass	1	1	500mmx700mmx2000mm	3	6

The ADA-inlet unit has the most complex geometry with one inlet and 4 outlets. The ADA-bypass comes next in complexity, as both units will have non-circular, irregular section with an average equivalent diameter of max 100mm. All ADA units except ADA-connection shall also be made of as many as required parts to enable installation on the aircraft depending on the number of compartment crossings (see table above). One challenge of this call for proposal is to determine and eventually test the appropriate material and associated manufacturing technique (thermoplastics, metal, 3D printing) while remaining compliant with all requirements to make it flight-worthy.

2. Manufacture two sets of ADA units. The Manufacturing process is the most challenging part requiring strong expertise and offering potential to experiments new techniques or implementation cases e.g. for thermoplastic manufacturing or 3D-metal-printing.
3. Qualify the ADA units to be flight-worthy according to Airbus standards for flight test components.
4. Deliver the two flight-worthy ADA complete units as per schedule:

Unit	Delivery Date
ADA-inlet	31.Jul.2015
ADA-connection	31.Jul.2015
ADA-outlet	31.Jul.2015
ADA-bypass	30.Sept.2015

The time schedule for unrolling the complete process from 3D geometry specification and mechanical installation requirements to component delivery runs from early 2014 to end of third quarter 2015.

3. Type of work

The ADA units described above shall be developed, manufactured and qualified for flight test according to Airbus Procedures. The challenge will be to determine the most appropriate material and associated manufacturing process for this complex duct geometry: composites, TP, metal 3D printing.

4. Special Skills, Certification or Equipment expected from the Applicant

Research Institute / SME or large company specialized in duct design, manufacturing techniques and qualification for aircraft. Integrating acoustical treatment into ducts can be included in the test component.

5. Major Deliverables and Schedule

Del. Ref. Nr.	Title	Description (if applicable)	Due
D1	Detailed Design Dossier for ADA-i+ADA-c+ADA-o compliant with Airbus Standards for Flight-Test-worthy parts		T0+6 months (≈ Nov 2014)
D2	Qualification Dossier for ADA-i+ADA-c+ADA-o compliant with Airbus Standards for Flight-Test-worthy parts		T0+11 months (≈ Apr 2015)
D3	Delivery of 2 ADA sets of ADA-i+ADA-c+ADA-o	2 sets of ADA-i+ADA-c+ADA-o, flight-worthy and ready to	T0+14 months (≈ Jul 2015)

		be installed on aircraft.	
D4	Detailed Design Dossier for ADA-b compliant with Airbus Standards for Flight-Test-worthy parts		T0+8 months (≈ Jan 2015)
D5	Qualification Dossier for ADA-b compliant with Airbus Standards for Flight-Test-worthy parts		T0+13 months (≈ Jun 2015)
D6	Delivery of 2 ADA-b units	2 ADA-b units, flight-worthy and ready to be installed on aircraft.	T0+16 months (≈ Sep 2015)

6. Topic value

The total value of biddings for this work package shall not exceed

250.000 €
[two hundred fifty thousand euro]

Please note that VAT is not applicable in the frame of the CleanSky program.

7. Remarks

The time schedule for this activity runs from Q2-2014 to Q3-2015, whereas the final delivery of the ducts end of September 2015 shall be seen as a deadline (i.e. cannot be shifted according to the actual test schedule).

Clean Sky – Technology Evaluator

No topics for Technology Evaluator