European Commission
Research Directorates

Call for Proposals:

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

Call Text

Call Identifier

SP1-JTI-CS-2013-01

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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.

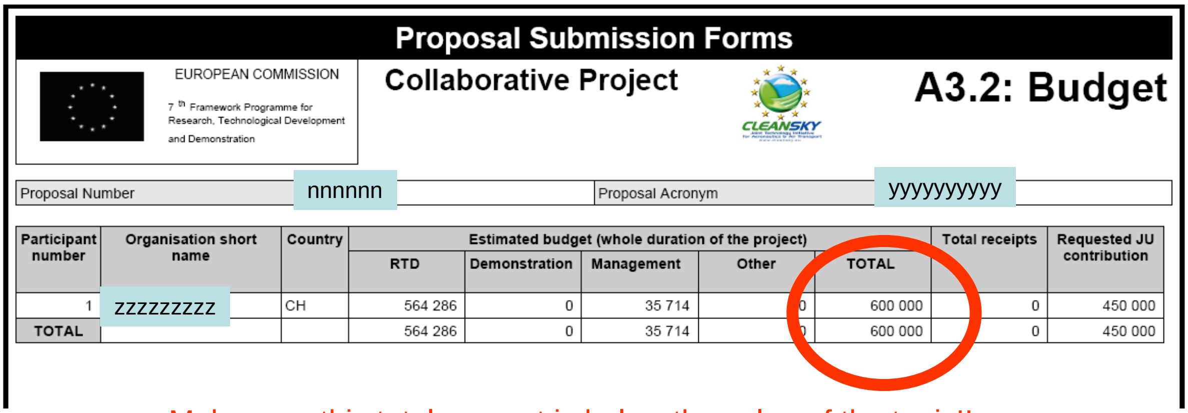
Each Topic fiche addresses the following points:

- Topic manager (not to be published)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.

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.

Recommendation to applicants:


Proposal Submission Forms

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

Collaborative Project

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

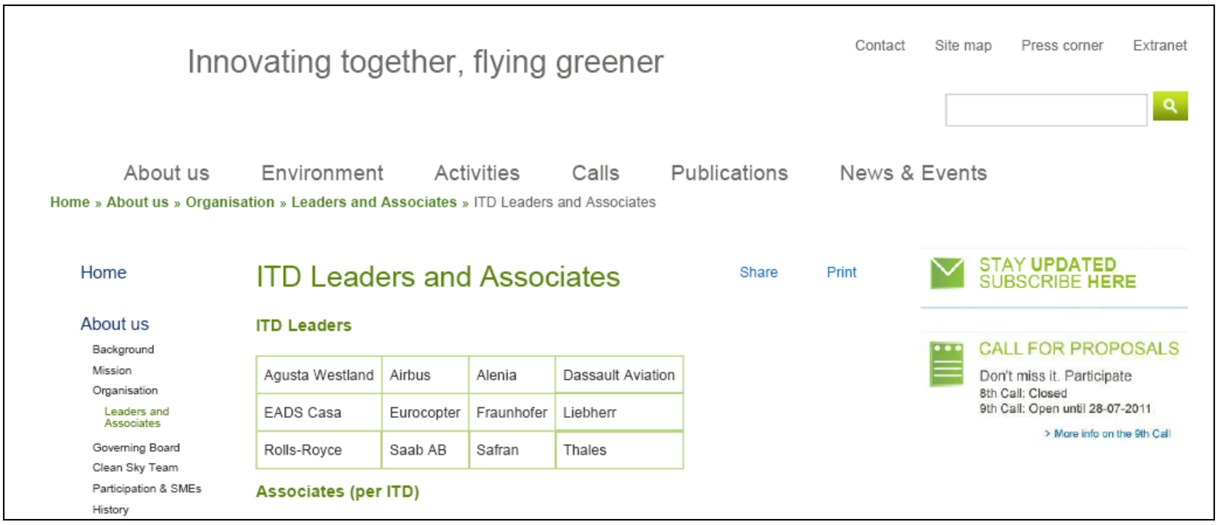
Make sure this total amount is below the value of the topic!!
Better, keep at least 5% margin below to be sure.
Final amount is to be discussed in the negotiation.

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.

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



<u>Recommendation to applicants:</u>

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: 17 January 2013**
- **Call close: 18 April 2013, 17:00 Brussels time**

- Evaluations (indicative): 13-17 May 2013

- Start of negotiations (indicative): 14 June 2013
- Final date for signature of GA by Partner: 12 July 2013
- Final date for signature of GA by Clean Sky JU: 31 July 2013

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://ec.europa.eu/research/participants/portal/appmanager/participants/portal)

Contacts:

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

info-call-2013-01@cleansky.eu

Questions received until **14 March 2013** will be considered.

A first version of the Q/A document will be released by **28 February 2013**.

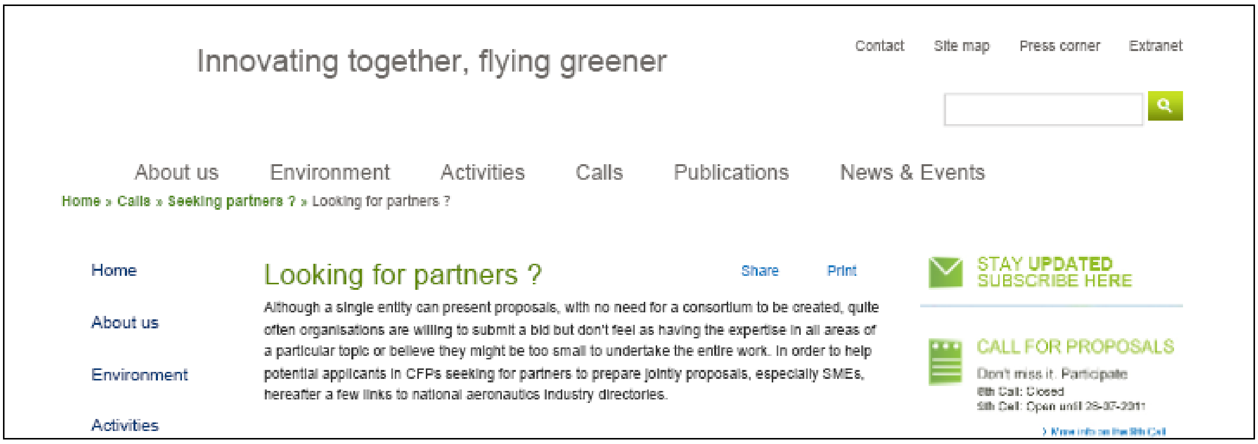
The final version of the Q/A document will be released by **end March 2013**.

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.

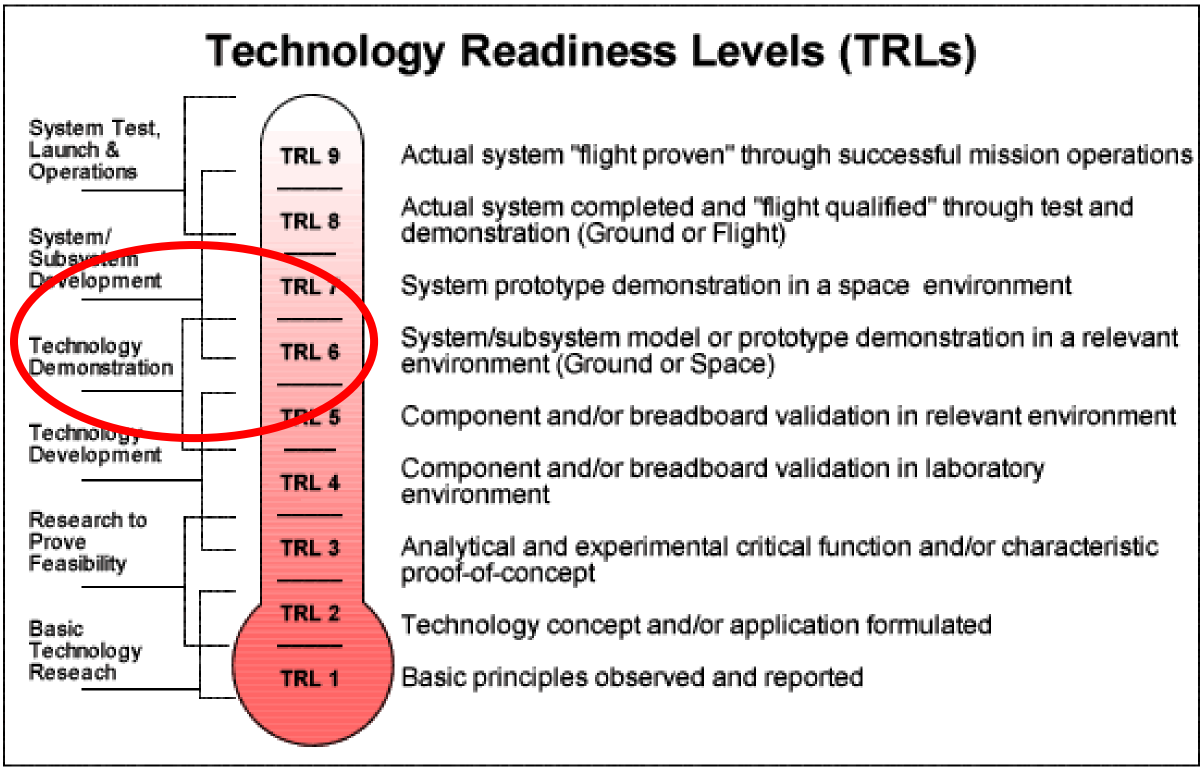
Looking for Partners?

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:



European Commission
Research Directorates

Clean Sky Joint Undertaking
Call SP1-JTI-CS-2013-01

Topic list table

Identification	ITD - AREA - TOPIC	topics	VALUE (€)	MAX FUND (€)
JTI-CS-ECO	**Clean Sky - EcoDesign**	**7**	**1,600,000**	**1,200,000**
JTI-CS-ECO-01	*Area-01 - EDA (Eco-Design for Airframe)*		**1,600,000**	
JTI-CS-2013-01-ECO-01-065	Extrapolation and Technical and economic study of a LBW technology		150,000	
JTI-CS-2013-01-ECO-01-066	Manufacturing by SLM of a titanium fan wheel. Comparison with a conventional manufacturing process.		200,000	
JTI-CS-2013-01-ECO-01-067	Manufacturing of high temperature composite parts for air cooling unit (e.g. cyanate ester / carbon fibres) by filament winding		200,000	
JTI-CS-2013-01-ECO-01-068	Manufacturing and optimisation of a PEEK scroll or body by fusible core injection moulding		250,000	
JTI-CS-2013-01-ECO-01-069	Characterization of metallurgical joining technologies for Al, Al-Li and Mg joints		200,000	
JTI-CS-2013-01-ECO-01-070	Application of sol gel technologies on low weight green metallic fuselage section		300,000	
JTI-CS-2013-01-ECO-01-071	Design and Modification of existing spraying facilities for automated sol gel application.		300,000	
JTI-CS-ECO-02	*Area-02 - EDS (Eco-Design for Systems)*			
JTI-CS-GRA	**Clean Sky - Green Regional Aircraft**	**4**	**6,420,000**	**4,815,000**
JTI-CS-GRA-01	*Area-01 - Low weight configurations*			
JTI-CS-GRA-02	*Area-02 - Low noise configurations*		**6,420,000**	
JTI-CS-2013-01-GRA-02-020	Aerodynamic experimental development and investigation on innovative Low-Noise A/C 90-pax configuration		2,400,000	
JTI-CS-2013-01-GRA-02-021	Optimization and highly-accurate/reliable demonstration of low-noise innovative Main Landing Gear		1,400,000	
JTI-CS-2013-01-GRA-02-022	Experimental investigation of advanced load control/alleviation technology in a regional a/c		2,400,000	
JTI-CS-2013-01-GRA-02-023	Development of methodology for structural& mechanical analysis on kinematics and actuators integration for loads control& alleviation		220,000	
JTI-CS-GRA-03	*Area-03 - All electric aircraft*			
JTI-CS-GRA-04	*Area-04 - Mission and trajectory Management*			
JTI-CS-GRA-05	*Area-05 - New configurations*			
JTI-CS-GRC	**Clean Sky - Green Rotorcraft**	**4**	**2,720,000**	**2,040,000**
JTI-CS-GRC-01	*Area-01 - Innovative Rotor Blades*		**320,000**	
JTI-CS-2013-01-GRC-01-014	Development and Testing of Computational Methods to Simulate Helicopter Rotors with Active Gurney Flap		320,000	
JTI-CS-GRC-02	*Area-02 - Reduced Drag of rotorcraft*		**900,000**	
JTI-CS-2013-01-GRC-02-016	Assessment of optimized tiltrotor engine intake performance by wind tunnel tests		450,000	
JTI-CS-2013-01-GRC-02-017	Contribution to the aerodynamic design of a helicopter air intake through wind tunnel testing		450,000	
JTI-CS-GRC-03	*Area-03 - Integration of innovative electrical systems*			
JTI-CS-GRC-04	*Area-04 - Installation of diesel engines on light helicopters*			
JTI-CS-GRC-05	*Area-05 - Environmentally friendly flight paths*		**1,500,000**	
JTI-CS-2013-01-GRC-05-008	Innovative measurement and monitoring system for accurate on-board acoustic predictions during rotorcraft approaches and departures		1,500,000	
JTI-CS-GRC-06	*Area-06 - Eco Design for Rotorcraft*			
JTI-CS-SAGE	**Clean Sky - Sustainable and Green Engines**	**17**	**22,100,000**	**16,575,000**
JTI-CS-SAGE-01	*Area-01 - Open Rotor Demo 1*			
JTI-CS-SAGE-02	*Area-02 - Open Rotor Demo 2*		**7,100,000**	
JTI-CS-2013-01-SAGE-02-030	Open Rotor propellers Ice Protection System.		2,000,000	
JTI-CS-2013-01-SAGE-02-031	SAGE2 Engine In-flight Balancing System		4,000,000	
JTI-CS-2013-01-SAGE-02-032	Study and durability of electrically insulative material in aircraft engine chemical environment		500,000	
JTI-CS-2013-01-SAGE-02-033	High speed metallic material removal under acceptable surface integrity for rotating frame		600,000	
JTI-CS-SAGE-03	*Area-03 - Large 3-shaft turbofan*		**4,450,000**	
JTI-CS-2013-01-SAGE-03-021	TCC Manifold Architecture Parametric Model development		600,000	
JTI-CS-2013-01-SAGE-03-022	Shared lubrication starting system		500,000	
JTI-CS-2013-01-SAGE-03-023	Microstructure Based Material Mechanical Models for Superalloys		850,000	
JTI-CS-2013-01-SAGE-03-024	Electric Pump for Safety Critical Aero engine applications		1,750,000	
JTI-CS-2013-01-SAGE-03-025	Variable fluid metering unit for Aero engine applications		750,000	
JTI-CS-SAGE-04	*Area-04 - Geared Turbofan*		**7,400,000**	
JTI-CS-2013-01-SAGE-04-020	Development of a robust forging process for a new advanced aero-engine rotor material		1,000,000	
JTI-CS-2013-01-SAGE-04-021	Development of an advanced forging process for optimised turbine casing material		600,000	
JTI-CS-2013-01-SAGE-04-022	Development of an advanced long life Ceramic Matrix Composite (CMC) turbine component		1,000,000	
JTI-CS-2013-01-SAGE-04-023	Development of a high flexible, low cost single crystal casting production process		1,500,000	
JTI-CS-2013-01-SAGE-04-024	Development of a Power Gearbox Rig		3,300,000	
JTI-CS-SAGE-05	*Area-05 - Turboshaft*			
JTI-CS-SAGE-06	*Area-06 - Lean Burner*		**3,150,000**	
JTI-CS-2013-01-SAGE-06-004	Design methods for low emissions		1,300,000	
JTI-CS-2013-01-SAGE-06-005	Design methods for durability and operability of low emissions combustor		850,000	
JTI-CS-2013-01-SAGE-06-006	Advanced materials for lean burn combustion system components using Laser- Additive Layer Manufacturing (L-ALM)		1,000,000	
JTI-CS-SFWA	**Clean Sky - Smart Fixed Wing Aircraft**	**2**	**3,000,000**	**2,250,000**
JTI-CS-SFWA-01	*Area01 – Smart Wing Technology*			
JTI-CS-SFWA-02	*Area02 - New Configuration*		**3,000,000**	
JTI-CS-2013-01-SFWA-02-038	Design and manufacturing of a representative new generation business jet model for high and low speed tests		2,000,000	
JTI-CS-2013-01-SFWA-02-041	Blade trajectory testing		1,000,000	
JTI-CS-SFWA-03	*Area03 – Flight Demonstrators*			
JTI-CS-SGO	**Clean Sky - Systems for Green Operations**	**20**	**10,500,000**	**7,875,000**
JTI-CS-SGO-01	*Area-01 - Definition of Aircraft Solutions and explotation strategies*			
JTI-CS-SGO-02	*Area-02 - Management of Aircraft Energy*		**6,250,000**	
JTI-CS-2013-01-SGO-02-051	Ram-air fan optimization for electrical ECS application		600,000	
JTI-CS-2013-01-SGO-02-056	Integrated design tool to support EWIS optimisation		300,000	
JTI-CS-2013-01-SGO-02-057	PWM High Voltage connectors		200,000	
JTI-CS-2013-01-SGO-02-058	Optimized power cable for skin effects		200,000	
JTI-CS-2013-01-SGO-02-061	Technology development and fabrication of integrated solid-state power switches		650,000	
JTI-CS-2013-01-SGO-02-064	Cooperative System Design Simulation Environment for Energy System Applications		250,000	
JTI-CS-2013-01-SGO-02-065	Modelica library of detailed magnetic effects in rotating machinery		250,000	
JTI-CS-2013-01-SGO-02-066	HVDC fuses design, development, validation and integration		400,000	
JTI-CS-2013-01-SGO-02-067	Optimized insulation for adapted characteristics		300,000	
JTI-CS-2013-01-SGO-02-068	Harness integrated sensors network for wiring health monitoring		500,000	
JTI-CS-2013-01-SGO-02-069	High power SiC diodes for Starter-Generator rotating rectifier bridge applications		600,000	
JTI-CS-2013-01-SGO-02-070	New magnetic materials for machines		600,000	
JTI-CS-2013-01-SGO-02-071	Bi-phase cooling system suitable for power electronics dedicated to more electrical aircraft		800,000	
JTI-CS-2013-01-SGO-02-072	Li-Ion battery for optimized DC network power conversion		600,000	
JTI-CS-SGO-03	*Area-03 - Management of Trajectory and Mission*		**2,050,000**	
JTI-CS-2013-01-SGO-03-021	Flight Operations for novel Continuous Descents		500,000	
JTI-CS-2013-01-SGO-03-022	Validation of avionic polarimetric radar X-band meteorological models and algorithms through experimental tests		1,000,000	
JTI-CS-2013-01-SGO-03-023	Simulation of Pilot Behaviour and Clearance Negatiation in Trajectory Changes Management		550,000	
JTI-CS-SGO-04	*Area-04 - Aircraft Demonstrators*		**2,200,000**	
JTI-CS-2013-01-SGO-04-006	Thermal Mock-ups for Thermal Management of a Ground Integration Test Rig		1,200,000	
JTI-CS-2013-01-SGO-04-007	Design and manufacturing of a 10kW AC-DC converter unit		500,000	
JTI-CS-2013-01-SGO-04-008	Electrical equipment modelling for test rig virtual integration		500,000	
JTI-CS-TEV	**Clean Sky - Technology Evaluator**	**0**	0	0.000
		topics	**VALUE**	**FUND**
	totals	**54**	**46,340,000**	**34,755,000**

Clean Sky – Eco Design

Identification	ITD - AREA - TOPIC	topics	VALUE (€)	MAX FUND (€)
JTI-CS-ECO	**Clean Sky - EcoDesign**	**7**	**1,600,000**	**1,200,000**
JTI-CS-ECO-01	*Area-01 - EDA (Eco-Design for Airframe)*		**1,600,000**	
JTI-CS-2013-01-ECO-01-065	Extrapolation and Technical and economic study of a LBW technology		150,000	
JTI-CS-2013-01-ECO-01-066	Manufacturing by SLM of a titanium fan wheel. Comparison with a conventional manufacturing process.		200,000	
JTI-CS-2013-01-ECO-01-067	Manufacturing of high temperature composite parts for air cooling unit (e.g. cyanate ester / carbon fibres) by filament winding		200,000	
JTI-CS-2013-01-ECO-01-068	Manufacturing and optimisation of a PEEK scroll or body by fusible core injection moulding		250,000	
JTI-CS-2013-01-ECO-01-069	Characterization of metallurgical joining technologies for Al, Al-Li and Mg joints		200,000	
JTI-CS-2013-01-ECO-01-070	Application of sol gel technologies on low weight green metallic fuselage section		300,000	
JTI-CS-2013-01-ECO-01-071	Design and Modification of existing spraying facilities for automated sol gel application.		300,000	
JTI-CS-ECO-02	*Area-02 - EDS (Eco-Design for Systems)*			

Topic Description

CfP topic number	Title		
JTI-CS-2013-01-ECO-01-065	Extrapolation and Technical and economic study of a LBW technology	**End date**	*To + 12*
		Start date	*To*

1. Topic Description

Recent interest in reducing the weight of aircraft has focused attention on the use of aluminium alloys and associated joining technologies.

Laser beam welding is one of the more promising methods for high speed welding of aluminium. Advanced aluminium alloys for aerospace applications can be welded, thus eliminating thousands of rivets resulting in a lighter and stronger integral structure.

At present, fuselage structures are joined by mechanical fastening (stiffened panels). These stiffened panels are light and highly resistant metal sheets designed to cope with a variety of loading conditions. Stiffeners improve the strength and stability of the structure and are able of slowing down or arresting the growth of cracks in the panel. Around 50.000 rivets are needed to join these elements, thus increasing the global weight of the structure.

Wings also consist in a skin-stringer-frame structure with the different elements joined together mechanically. Apart from adding weight to the aircraft structure, the mechanical fasteners mean a source of galvanic corrosion that limits the life of these elements.

The 1st objective is the study of extrapolation of a LBW system to industrial conditions:

This study will be concentrated on an explicit process description and flow incorporating all involved materials as well as tools, peripherals and auxiliary equipment, the exact process steps and the involved parameters in each step, ending up in the final outcome of the process, which will be specified by the Topic manager. The outcome will be typical aircraft structure (e.g. fuselage skin configuration with stringers). The reference benchmark process will be the traditional riveting for the very same aircraft structure. The LBW equipment to be considered shall be of an industrial type, capable of being integrated in a production line.

The 2nd objective of this call is to issue technical and economic feasibility study of LBW technology:

The methodology adopted and the analysis performed shall address the possibility to industrialize the process in a real environment by establishing the minimum conditions (e.g. productivity rates) required to make that viable. Issues of man power and training required shall also be investigated. The path to bring the process to the production phase shall be evaluated in a formulated implementation plan by taking into consideration the recurring and non-recurring costs. The required equipment/layouts and possible modifications of existing industrial plant and studying the technical and economical impact deriving from its introduction shall be dealt with.

The industrial repercussion during the implementation of the process in the manufacturing plant will also need to be coped with.

An essential aspect within this objective will be the assessment of the environmental footprint of the new technology, in which the following parameters should be recorded: Consumption of all materials, Energy consumption, Consumables, Operating materials and others, Outputs per reference product unit, all sorts of emissions to environment, all sorts of produced waste (material, heat (for recovery)), identification of any hazardous waste, and recyclability of waste.

A risk assessment plan will be produced and the manufacturing plan for end item top assembly shall be elaborated.

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

The following skills and equipment are required:
- Laser Beam Welding know how.
- Proven Background and knowledge on laser welding of structural aerospace aluminium alloys
- Experience in technologies industrialization.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Feasibility of the process in the real industrial environment	To perform a benchmarking of existing industrial plant potentially suitable for the process	T_0 + 2
D2	Path to bring the selected industrial equipment to the production phase of the laser beam welding process	To evaluate the implementation plan, To evaluate the industrial repercussion during the implementation of the technology in the manufacturing plant	T_0 +4
D3	Technical and economic impact	Evaluation of the technical and economic impact from the introduction of the selected technology, compared to the existing alternative technologies (cost / performance evaluation). Establish the minimum conditions required to make the technology viable. Cost analysis with recurring and non-recurring cost (RC & NRC) analysis for this process.	T_0 + 5
D4	Relevant parameters of the environmental impact during the production cycle	Evaluate the relevant parameters of their impact on the environment during the production cycle with reference to the healthy human oriented working.	T_0 + 6
D5	Risk assessment plan	Establish risk assessment plan of the entire production process	T_0 + 9
D6	Manufacturing plan.	Elaborate the manufacturing plan for end item top assembly.	T_0 + 10
D7	Process procedures and standard manual	To develop the process procedures and standard manual for the industrial application	T_0 + 11
D8	Final report.	Report on the extrapolation to industrial condition of the laser beam welding process	T_0 + 12

4. Topic value (€)

The total value of this work shall not exceed:

150,000 €

[One Hundred and Fifty Thousand Euro]

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

5. Remarks

Raw material will be provided by Topic Manager

Topic Description

CfP topic number	Title		
JTI-CS-2013-1-ECO-01-066	Manufacturing by SLM of a titanium fan wheel. Comparison with a conventional manufacturing process.	**Start date**	*To + 18*
		End date	*To*

1. Topic Description

Today, the fan wheel of an air cooling unit is made of stainless steel.

In order to reduce weight and improve corrosion resistance, the topic manager would like to manufacture this wheel with *titanium alloy TA6V*.

Moreover, *Selective Laser Melting (SLM)* is an environmental friendly process as it reduces machining (scrap rate), buy-to-fly ratio and is less energy consuming.

The aim of this call is to find partner(s) able to develop a manufacturing process for a fan titanium TA6V wheel by SLM. The innovative technology (SLM) will be compared to a more conventional process (bar machining) in terms of materials properties (Rm, Rp0.2, E, E%, fatigue, surface roughness, corrosion resistance…), environmental impact (Life Cycle Assessment) and cost.

To this end, the following steps shall be performed by the applicant:

- To analyse requirements of the topic manager. Requirements will be shared with the applicant(s) at the beginning of the project. The wheel is composed of 15 blades, its diameter is between 200 and 250mm and its length is around 40mm,

- To develop a methodology to manufacture the wheel and the control samples by SLM.

- To study the effect of surface roughness on fatigue properties & corrosion resistance. Optimize process parameters accordingly, eventually adding a surface finishing step.

- To compare samples properties obtained by optimized SLM process and by bar machining (provided by the topic manager): mechanical properties (Rm, Rp0.2, E, E%, fatigue…), corrosion resistance and metallurgical analysis.

At this step the topic manager, with the support of the applicant, will perform stress calculations to optimize the fan wheel design for SLM.

- To manufacture 5 fan wheels demonstrators by SLM and compare them with fan wheel manufactured by bar machining: weight, geometry, homogeneity, surface roughness, aerodynamic performances (this last point will be assessed by the topic manager).

- To compare both processes (SLM and bar machining) in terms of environmental performance (LCA) and cost.

The partner(s) shall have the capacity to transfer the process to an industrial scale.

TRL5 is expected at the end of the project.

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

The applicant(s) should have the following facilities and knowledge:

- Extensive experience and strong knowledge on titanium alloy, particularly TA6V
- Extensive experience and strong knowledge on SLM, particularly for TA6V
- Extensive experience and strong knowledge on surface finishing after SLM, particularly on TA6V
- Capabilities for SLM and surface finishing,
- Extensive experience on and capabilities for mechanical testing (tensile and fatigue testing), metallurgical characterisation of titanium alloys, surface roughness measurements
- Facilities for implementing the processes in an industrial scale

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Analyse of the requirements and proposal of a methodology for manufacturing fan wheels and control samples by SLM	Report	To + 2
D2	Report on the effect of surface roughness on fatigue properties & corrosion resistance	Report	T0 + 10
D3	Manufacturing of first prototypes and control samples	First prototypes and control samples	T0 + 10
D4	Mechanical and metallurgical properties of control samples (SLM and bar machining)	Test Report	To + 12
D5	Destructive and non-destructive control of the first prototypes (geometry, identification of defects, metallurgy, mechanical properties)	Report	To + 12
D6	Manufacturing of fan wheels demonstrators with optimised design & process parameters by SLM	Demonstrators	To + 16
D7	Control of the final demonstrators (weight, geometry, homogeneity)	Report	To + 18
D8	Synthesis report: comparison of SLM & bar machining process	Report	To + 18

4. Topic value (€)

The total value of 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.

Clean Sky Joint Undertaking
SP1-JTI-CS-2013-01-ECO-01-067

Topic Description

CfP topic number	Title		
JTI-CS-2013-1-ECO-01-067	Manufacturing of high temperature composite parts for air cooling unit (e.g. cyanate ester / carbon fibres) by filament winding	**End date**	*To + 18*
		Start date	*To*

1. Topic Description

Some components of aircrafts air cooling units are subjected to highly variable environmental constraints: temperatures between -50°C and 250°C and moisture.

Most of these components are currently made out of metallic alloys.

In the case of rotors parts (e.g. sleeves), an innovative solution to reduce weight and allow higher speed rotation at elevated temperature is to replace metallic parts by continuous fibre-reinforced polymers parts.

Cyanate ester resins reinforced by carbon fibres are good candidates for this application.

They have a glass transition temperature (Tg) which exceeds those of epoxy resins and high resistance to moisture absorption after curing. Processing of these composites is very difficult as the resin is very sensitive to ambient conditions (reaction with moisture before curing, oxidation degradation during post-curing) and many cautions have to be taken to ensure reproducibility of the process and its transfer to an industrial scale. In particular, in the case of filament winding with cyanate ester resins, moisture contact has to be carefully managed and specific adaptations of the process have to be found. The aim of this call is to find partners who will develop an adapted filament winding process to manufacture rotor parts (e.g. sleeves) with cyanate ester resin and carbon fibres. Detailed requirements, design of the parts, data on materials used, will be given to the applicant at the beginning of the project. Dimensions of the part are around 100mm long, 60mm diameter and 5mm thickness.

The most important constraints are:

- The sleeve is a part of a rotor which is composed of different materials having different thermal expansion coefficients. Strain/stress induced by thermal expansion has to be considered at the beginning of conception and process definition to get the required geometry for the part after curing.

- The thickness of the sleeve must be homogeneous, with low porosity all along the part and a good compliance with the theoretical ply stacking.

- The sleeve shall withstand high temperature (250°C), high strengths and high speed rotation.

The following steps shall be performed by the applicant:

1- Analysis of requirements, current designs and constraints. Proposal of a manufacturing concept based on the given technological bricks (filament winding, cyanate ester based composites, process control,…) with a pre-assessment of recurrent and non-recurrent costs.

2- Thermo-mechanical calculations and lay-up design accordingly. Stresses evaluation through temperature and rotation speed spectrum seen by the sleeve during operation.

3- Methodology development of cyanate ester resin filament winding process ensuring less than 3% void rate and carefully managing moisture.

4- Process monitoring with real-time control of parameters, especially those of the impregnation/gelation phase and the carbon ribbon tension.

5- Manufacturing of prototypes. Perform the necessary geometrical control & health assessment by destructive & non-destructive technologies.

6- Process optimisation and manufacturing of 5 final demonstrators.

The partner(s) shall have the capacity to transfer the process to an industrial scale.TRL5 is expected at the end of the project.

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

The applicant should have the following knowledge & equipment:

- Strong knowledge and extensive experience on cyanate ester based composites and their processing (prepreg, RTM,…)
- Strong knowledge, extensive experience on and capabilities for manufacturing thermoset composites
- Strong experience in composite process optimisation
- Strong knowledge, extensive experience and capabilities to characterize cured and uncured resins properties (Tg, DSC, DMA, viscosity, mechanical testing …)
- Strong knowledge and extensive experience on composite winding machine
- Strong knowledge and extensive experience on composite calculation & process simulation
- Strain gauge experience on composite application in order to validate calculation results
- Strain gauge measurement tooling for instrumentation of processing
- Facilities for implementing the process in an industrial scale (small batches)

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Report on the manufacturing process proposed according to requirements and constraints	Report	To + 3
D2	Report on mechanical and thermo-mechanical calculations. Proposal on a new design.	Report	To + 6
D3	Prototypes manufacturing and characterization report	Test Report	To + 9
D4	Report on the optimization of the process and characterization	Report	To + 12
D5	Manufacturing of 5 demonstrators	Demonstrators	To + 18
D6	Synthesis report	Report	To + 18

4. Topic value (€)

The total value of 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.

Clean Sky Joint Undertaking
SP1-JTI-CS-2013-01-ECO-01-068

Topic Description

CfP topic number	Title		
JTI-CS-2013-1-ECO-01-068	Manufacturing and optimisation of a PEEK scroll or body by fusible core injection moulding	**Start date**	*To + 18*
		End date	*To*

1. Topic Description

One of the main components from an Electrical-Environmental Control System (E-ECS) is a Motorized Turbo Compressor (MTC).

Today the MTC scroll and body are manufactured by Aluminium casting.

In order to reduce weight and improve corrosion resistance (to avoid surface treatments), the Topic manager would like to manufacture these parts with carbon fibres reinforced thermoplastic (PEEK).

The parts are quite complex in shape, with hollows, thus the partner(s) shall work on the innovative fusible core process.

The aim of this call is to find partner(s) able to develop an innovative manufacturing process for a *Motorized Turbo Compressor (MTC)* scroll and/or a body by reinforced thermoplastic injection moulding.

The thermoplastic will be a PEEK.

The dimensions of the scroll are between 200 and 300mm in diameter and 100mm width; the dimensions of the body are around 300mm diameter and 200mm length.

The following steps should be performed by the applicant:

- To analyse the topic manager requirements
- To manufacture samples by injection moulding with the defined reinforced TP
- To perform mechanical testing on samples

At this step, stress calculation and definition on a new design will be performed by the topic manager.

- To design and manufacture the mould and the fusible core, this step will require rheological simulations
- To inject first prototypes and characterize them with destructive and non-destructive technologies (e.g. tomography) in terms of thickness homogeneity, geometry, identification of potential defects (porosity, fibres repartition,...),
- To optimize the mould, the fusible core & process parameters accordingly
- To manufacture 10 demonstrators (scroll and/or body)
- To compare the innovative developed process with current conventional process (aluminium casting) in terms of environmental impact (Life Cycle Assessment) and costs.

The partner(s) shall have the capacity to transfer the process to an industrial scale.

TRL5 is expected at the end of the project.

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

The applicant(s) should have the following facilities and knowledge:

- Extensive experience and strong knowledge on thermoplastic injection moulding (injection process, design and manufacturing of the moulds, calculation)
- Extensive experience and strong knowledge on fusible core technology
- Strong knowledge of carbon fibres reinforced thermoplastics
- Capabilities for injection moulding and mould design and manufacturing
- Extensive experience on and capabilities for characterisations (mechanical properties, thickness homogeneity, geometry, identification of potential defects) by destructive and non-destructive technologies of reinforced thermoplastics
- Facilities for implementing the processes in an industrial scale.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Analysis of the requirements	Report	To + 1
D2	Manufacturing of samples for characterization	Samples	To + 3
D3	Mechanical properties	Report	To + 4
D4	Design of the mould and fusible core and rheological simulations results	Drawings + Report	To + 8
D5	Manufacturing of the mould	Mould	To +11
D6	Manufacturing of first prototypes	First prototypes	To + 13
D7	Control of the parts with destructive and non-destructive technologies (e.g. tomography thickness homogeneity, geometry, identification of potential defects (porosity, fibre repartition,...)	Report	To + 15
D8	Optimization of the mould & fusible core design, process parameters	Report	To + 16
D9	Manufacturing of demonstrators	Demonstrators	To + 17
D10	Control of the final demonstrators with destructive and non-destructive technologies (e.g. tomography thickness homogeneity, geometry, identification of potential defects (porosity, fibre repartition,...)	Report	To + 18
D11	Report on comparison of the innovative developed process with current conventional process (aluminium casting)	Report	To + 18

4. Topic value (€)

The total value of 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.

Clean Sky Joint Undertaking
SP1-JTI-CS-2013-01-ECO-01-069

Topic Description

CfP topic number	Title		
JTI-CS-2013-1-ECO-01-069	Characterization of metallurgical joining technologies for Al, Al-Li and Mg joints	End date	*To + 16*
		Start date	*To*

1. Topic Description

As part of the effort to decrease the environmental impact of metallic aero-structures, assembly aspects should be considered as well, in favour of the elimination of the riveting process.

Alternative technologies, such as Laser Beam Welding (LBW) are developed for the joining of Al alloys and are especially tempting to use with newly developed light alloys, like Al- Li and Mg to offer eco-efficient structures, both by reducing weight by using lighter and stronger materials and minimizing the use of vast amount of rivets. In the frame of the Clean Sky Eco-Design platform, it is planned to develop and manufacture a light weight green metallic fuselage section demonstrator and to use Al-Li alloys and improved Mg alloys.

The objective of the call is to develop and adapt joining technologies for the following relevant pairs: Al with Al/Al-Li alloys, Al/Al-Li with Mg alloys and to implement them in a part of the demonstrator (panel).

Two technologies would like to be examined: Laser Beam Welding (LBW) and Resistance Spot Welding (RSW) as they have the potential to provide healthy joints. LBW enables the joining of dissimilar alloys especially as Al and Mg do have a workable solubility range. RSW when applied through the sealant enables electrical conductive joints free of galvanic corrosion problems.

Weldability problems that may be encountered are: porosity, hot cracking and others arising from dissimilar metal joining.

The partner who will be selected shall perform the following activities:

a) A trade off study for the state of the art of joining technologies for Al, Al-Li and Mg alloys.

b) Evaluate the joining quality by performing the following tests and inspections:
- Static mechanical properties (tensile test) – UTS, TYS, Shear strength
- Dynamic properties (fatigue test) – S/N curve
- Corrosion behaviour of the joints – SST, Galvanic corrosion tests and humidity tests
- Metallographic characterization of joints
- NDT evaluation for the soundness of the joints

c) Apply the selected technology on a panel demonstrator.

Note: Every test of the above has to include at least 5 specimens (fatigue test will include 5 samples per load, 5 loads required) and every test must have a reference to riveted samples.
The materials for the testing, the joining and the panel will be provided by the topic manager. The applicant will prepare the specimens according to test requirements.

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

The following skills and equipment are required:

- Laser Beam Welding facility
- Resistance Spot Welding facility
- Proven background and wide knowledge on LBW and RSW of structural aerospace Al and Mg alloys
- Experience for microstructure characterization and mechanical (static and dynamic) testing of welded joints
- Salt spray and humidity test chambers
- NDT facilities and approved personnel in Radiography, Liquid Penetrant and Eddy Current testing

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Trade off study (Report)	Trade off study for the state of the art of joining technologies for Al, Al-Li and Mg alloys	To + 1.5 Months
D2	Evaluation of joining	Joining of Al with Al/Al-Li alloys and Mg with Al/Al-Li alloys	To + 4 Months
D3	Static tests and NDT inspection (Report)	Static test report with metallographic characterization and NDT results	To + 6 Months
D4	Corrosion tests (Report)	Salt Spray Test, Humidity tests and Galvanic corrosion including pictures	To + 8 Months
D5	Dynamic tests (Report)	S/N curves	To + 10 Months
D6	Panel preparation	Apply selected technology on an estimated 30cm X 80cm panel	To + 14 Months
D7	Final report (Report)	Contain results of D2-D6 including conclusions and recommendation	To + 16 Months

4. Topic value (€)

The total value of this work package shall not exceed:

200,000 €
Two Hundred Thousand Euros

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

5. Remarks

The considered alloys are: Al-Li as 2198, Al as 2024 and Mg as WE43

Topic Description

CfP topic number	Title		
JTI-CS-2013-1-ECO-01-070	Application of sol gel technologies on low weight green metallic fuselage section	**End date**	*To + 24*
		Start date	*To*

1. Topic Description

The call is aiming at the development of a two component spray or stick/brush devices dedicated to the application of thin sol gel products to improve paint adhesion on large surface for OEM or on small to very small surfaces for MRO.

Sol gel products can be considered as a multicomponent system which builds up a 3D film through a two steps process (hydrolysis and condensation/grafting). The consequence is a complex process with a combination of mixing, induction time and pot life issues which may be handled for spray application process on very large surface but not for very small surface. A solution like most of the chemical conversion coating currently used is to imagine a two component application device which can integrate in a chamber the mixing just prior application. This chamber could be a non-reusable device.

The applicant shall deliver:

* A mixing ratio of the different components with appropriate accuracy. The mixture shall be applied by a stick or brush. All components shall resist to the mixture and the applicant shall prove that all components and materials have no adverse effect on the final properties of the sol gel coating

* The design of a mixing chamber in order to provide a discrete or continuous supply of the component allowing the wide range of application field from OEM to MRO

* Control of the hydrolysis phase from the mixing chamber to the nozzle with respect to the addition of acid catalyst. A clear synthesis on the role of acidity on the kinetic and the film formation shall be provided

* The resulting properties will be compared to the complex conventional process (chemical profile in the volume of the sol gel film, wet adhesion of paint, filiform corrosion, crevice corrosion)

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

Special skills:

- Good knowledge of sol gel film (formulation, film formation).
- Design of mixing chamber
- Selection of material resistant to sol gel composition without any adverse effect on the ratio of precursors.
- Control of hydrolysis, condensation of sol gel
- Good knowledge of aeronautical practises especially concerning repair procedure and surface treatment of light alloys.
- Formulation of sol gel
- Characterization of resulting film

Equipment and infrastructure:

Lab equipment for formulation

Manufacturing tools for the devices

Analytical devices to control hydrolysis, condensation/grafting and kinetic

Assessment of resulting film

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Kinetic of hydrolysis and pot life	Report on the chemistry, kinetic	To+6
D2	Formulation of sol gel with very short induction time	Sample	T0+10
D3	Design of application devices	Demonstrator for application	T0+12
D4	Stability of the product	Report	T0+18
D5	Demonstrator and film performances	Report and performances Demonstrator complex shapes	T0+24

4. Topic value (€)

The total value of 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.

Clean Sky Joint Undertaking
SP1-JTI-CS-2013-01-ECO-01-071

Topic Description

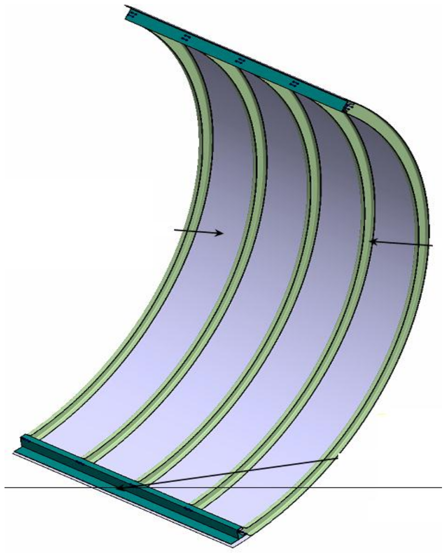
CfP topic number	Title		
JTI-CS-2013-1-ECO-01-071	Design and Modification of existing spraying facilities for automated sol gel application.	**End date**	*To + 8*
		Start date	*To*

1. Topic Description

A sol gel process is based on precipitation of organo functionalized alkoxydes in presence of acid or alkaline catalyst using precursors such as silane, silicate, zirconate or titanate. Sol gel coatings are eliminating the use of Crvi toxic and carcinogenic compounds. The concept is to replace the existing protection system anodising+paint which includes Cr compounds and to develop spraying techniques in replacement of in-bath ones, using green products. This will permit the treatment of very large parts, or welded ones, while suppressing huge tanks containing hazardous products and allowing the reduction of water consumption and of waste.

The objective of this CfP is to investigate and modify existing equipment (as a standard manual spraying system including: high speed spray gun, compressed air facility, water curtain installation in an enclosed area) to achieve an automated sol gel system with robotic capabilities (preferably five axis movements). The study will be performed in the frame of sol gel technology extrapolation to industrial conditions phase. For this purpose, the existing equipment will be available for modifications on CfP originator site. The robotic system will be property of CfP originator after the termination of the project. The final system will be tested and approved in CFP originator facilities. Series of coupons and limited number of components will be used for sol gel robotic spraying technology approval tests. The coating experiments will be performed on conditions specified by topic manager and the coated products will simulate stiffened structures and inspected T in order to assure the quality of coating in respect to uniform coverage.

The system will be applied for the spraying of a curved component (of dimensions 1500 x 2100 mm with a Radius of 137 DEG. Spray gun may be movable over rails), as depicted below after:



The Al alloy coupons and components will be provided by the Topic Manager.

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

The following skills and equipment are required:

- Robotic systems know how.
- Experience on spraying applications
- Know How on machinery modifications, custom-made tooling systems design and realization capabilities.

Equipment and infrastructure:

Lab equipment for formulation Manufacturing tools for the devices Analytical devices to control hydrolysis, condensation/grafting and kinetic Assessment of resulting film

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Design of modification of existing equipment to new technology system.	Report and drawings	T0+2
D2	Modification of existing equipment (1)	New robotic sol gel pre-validated system	T0+4
D3	Production and delivery of coated test coupons in forms representative real aeronautical skin structures (at least five coupons dimensions 250 x 250 mm). Report and reference standards shall be included.	Coupons (at least 3 different configuration)	T0+5
D4	Thickness and Uniformity evaluation on sol gel coated coupons and components.	Report	T0+7
D5	Modification of existing equipment (2-final)	New robotic system (key in hand training, Maintenance and Instructions manuals)	T0 + 8
D6	Training of CfP originator personnel on spraying with the robotic system, system programming and system maintenance	New robotic system (key in hand training and Instructions manuals)	T0 + 8

4. Topic value (€)

The total value of 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.

5. Remarks

Raw material will be provided by CfP originator

Clean Sky – Green Regional Aircraft

Identification	ITD - AREA - TOPIC	topics	VALUE (€)	MAX FUND (€)
JTI-CS-GRA	**Clean Sky - Green Regional Aircraft**	**4**	**6,420,000**	**4,815,000**
JTI-CS-GRA-01	*Area-01 - Low weight configurations*			
JTI-CS-GRA-02	*Area-02 - Low noise configurations*		**6,420,000**	
JTI-CS-2013-01-GRA-02-020	Aerodynamic experimental development and investigation on innovative Low-Noise A/C 90-pax configuration		2,400,000	
JTI-CS-2013-01-GRA-02-021	Optimization and highly-accurate/reliable demonstration of low-noise innovative Main Landing Gear		1,400,000	
JTI-CS-2013-01-GRA-02-022	Experimental investigation of advanced load control/alleviation technology in a regional a/c		2,400,000	
JTI-CS-2013-01-GRA-02-023	Development of methodology for structural& mechanical analysis on kinematics and actuators integration for loads control& alleviation		220,000	
JTI-CS-GRA-03	*Area-03 - All electric aircraft*			
JTI-CS-GRA-04	*Area-04 - Mission and trajectory Management*			
JTI-CS-GRA-05	*Area-05 - New configurations*			

Topic Description

CfP topic number	Title		
JTI-CS-2013-01-GRA-02-020	Experimental Optimization and Assessment of an Advanced Turbo Prop Regional Aircraft through Innovative Complete Aircraft Powered Wind Tunnel Model	**Start date**	T_0 (**)
		End date	T_0 + 24

Note (**): T_0 is the effective date of contract

1. Topic Description

Short Description

An advanced Turbo Prop 90-seat regional aircraft configuration should be experimentally investigated through low-speed aerodynamic WT tests on a complete powered model. Within this test campaign the S&C data set of the A/C will be assessed, and the high-lift performances in both take-off and landing conditions evaluated as well.

In this context, main activities being the subject of the concerned topic are as follows:

- Design and manufacturing of a a complete aircraft powered WT model, representative of the full-size configuration of a Turbo Prop 90-seat regional A/C, equipped with engine-nacelles, propellers, high-lift devices, control surfaces, winglets and landing gears (simplified geometry).

- Aerodynamic WT tests on the aircraft model at low-speed (Mach ≈ 0.2) with model scale not less than 1:7 (full-size, full-span length ≈ 29m - Aspect Ratio ≈10.6) with the aims to:

- Assess the whole aircraft architecture in terms of stability and control at different thrust conditions, by considering different shapes/installed configurations of engine nacelles;

- Validate at take-off and approach conditions the A/C high-lift design performances.

1.1 Introduction

1.1.1 Background

Within the “Low Noise Configuration” (LNC) domain of the Green Regional Aircraft ITD advanced technologies tailored to future regional airliners are being developed tailored to several A/C configurations with different power plant architectures. The final aim is to contribute to reduce the environmental impact of regional air transport over next decades, according to the strategic road map stated in the “Vision 2020” by ACARE.

In particular, technology innovation toward paramount concepts for a next-generation green Turbo-Prop 90-seat regional A/C configuration is considered, such as:

i) highly-efficient wing aerodynamics;

ii) Innovative high lift system design to reduce noise while preserving high lift performance.

1.1.2 Interfaces to ITD

The activity subject of the present Call for Proposals is concerning with the experimental validation in wind tunnel of low-speed aerodynamic performances of a Turbo Prop 90-seat regional A/C. To this aim a complete powered A/C WT model equipped with engine-nacelles, propeller blades, high-lift devices, control surfaces, winglets and landing gears (simplified architecture), as developed in the frame of the GRA ITD, will be designed, manufactured and tested in a suitable experimental facility.

The input/output geometrical model data exchange will be handled through standard formats (IGES, CATIA, and NASTRAN). The wind tunnel tests output data will be handled through technical reports and standard format on DVD.

1.2 Scope of Work

Topics and expected outcomes of the activity inherent to the present CfP are dealing with:

i) D&M of a complete aircraft powered WT model, representative of the full-size configuration of a Turbo Prop 90-seat regional A/C, equipped with engine-nacelles, propeller blades, high-lift devices, control surfaces, winglets and nose and main landing gears (simplified shapes).

ii) Aerodynamic WT tests on the above aircraft model at low-speed (up to Mach ≈ 0.2). with model scale not less than 1:7 (full-size, full-span length ≈ 29m - Aspect Ratio ≈10.6) with the aims to:

- Assess the whole aircraft architecture in terms of stability and control at different thrust conditions by also evaluating the effect of different shapes/installation solutions of engine nacelles;

- Power-plant optimisation (i.e evaluation of the the effect of the nacelle design / intregration)

- Validate at take-off and approach conditions the A/C high-lift design performances.

1.3 Type of Work

It consists of: Mechanical design and structural (FEM) modelling of the aircraft WT model, aero-elasticity analyses, wind tunnel testing and experimental data acquisition.

1.4 Abbreviations & Definitions

A/C	Aircraft
ACARE	Advisory Council for Aerospace Research in Europe
CAD	Computer Aided Design
CDR	Critical Design Review
CFD	Computational Fluid Dynamics
CfP	Call for Proposals
CSM	Computational Structural Mechanics
CT	Thrust Coefficient
D&M	Design & Manufacturing
FEM	Finite Element Model
GRA	Green Regional Aircraft
HLD	High Lift Device
HW	Hardware
IB	Inboard
ITD	Integrated Technology Demonstrator
JTI	Joint Technology Initiative
LNC	Low Noise Configuration (one of the projects of the GRA ITD)
Mach	Mach number
OB	Outboard
PDR	Preliminary Design Review
T/E	Trailing Edge
TP	Turbo Prop
WP	Work Package
WT	Wind Tunnel
WTT	Wind Tunnel Tests

1.5 Description of Work

According to the objectives described in par. 1.2, the concerned activity will develop through several work packages as described hereinafter.

1.5.1 WP 1 – WT Model Mechanical Design & Manufacturing

Task 1.1 - Mechanical Design of WT Model

<u>Inputs</u>:

i) Full-scale TP aircraft configuration CAD geometry
ii) Baseline nacelle and propeller CAD geometries
iii) Wind Tunnel model requirements

iv) Technical specification for WT testing

The first phase of the required work will be dealing with the mechanical design of the A/C modular wind tunnel model. Based on the choice of the wind tunnel (which is up to the Applicant), the model scale will be defined by considering the opposite needs of reaching adequate test conditions in terms of Reynolds number on one side, and of keeping the engine simulator power requirements within reasonable limits on the other side. The scale model, however, has to be not less than 1:7. A sketch of the aircraft configuration is shown in figure 1.

Figure 1 – Pictorial image of future green TP regional aircraft

The model will be modular to cope with the following tail-on/tail-off, propellers on/off and landing gears in/out configurations, all inclusive of movable surfaces:

a) Fuselage + Wing + engines (*)
b) Fuselage + Wing + engines + Vertical Tail
c) Fuselage + Wing + engines + Vertical Tail + Horizontal Tail (complete A/C architecture)

(*) engine simulator + nacelle + propeller

Ailerons, trailing edge Flaps, Elevator, Rudder and Airbrake/Spoilers have to be considered. All aerodynamic control movables, both primary and secondary surfaces, are required to be set in discrete deflected positions. As it concerns HLD various gap/overlap combinations have to be tested trying to find the optimal flap setting. Use of brackets to connect movable control surfaces to relevant fixed parts can be used as a reference solution. Use of remote powered actuation can be anyway taken into account when such a solution brings advantages in terms of time/cost reduction.
In addition to the conventional T/E flap architecture, a so-called lined flap will have to be manufactured and tested. This latter is an innovative acoustically treated flap design conceived to reduce airframe noise. Relevant design requirements specification will be provided by the ITD Member. Aims of relevant tests is to verify possible penalty in terms of high-lift performance due to this type of flap structure (with micro-perforation on the external surface)

The A/C WT model will have to be designed and built in such a way to minimize deformations, during testing within the specified speed and incidence ranges, which will have not to exceed following values:

i) 1% (one per cent) model span measured at wing tip at maximum loading;
ii) 1% (one per cent) fuselage bow measured at nose and tail cone at maximum normal/bending loading.

Compliance with the above requirements shall be provided by the model designer by means of a specific technical report.

The following tolerances, intended as difference between the achieved (measured) value and the nominal one, shall be used:

1) Tolerance (Δz) over model external surface:	0.10 mm
2) Tolerance (Δz) over model overall vertical dimension:	2.00 mm
3) Tolerance (Δy) over model overall side dimensions:	2.00 mm
4) Tolerance (Δy) over model overall lateral asymmetry:	1.00 mm
5) Tolerance (Δy) over model overall longitudinal asymmetry:	1.00 mm
6) Tolerance (Δx) over model overall length:	3.00 mm
7) Tolerance (Δ°) over movable surfaces deflection:	0.5 deg
8) Tolerance (Δx, Δy, Δz) over relative fixed to movable parts position:	0.5 mm

Outputs:

a) Aircraft WT model design report and CAD Files – **Deliverable D1.1.1**
b) Aircraft WT stress analysis report – **Deliverable D1.1.2**

Task 1.2 - Model Propulsion System

Inputs:

i) Nacelle geometry

ii) Blades geometry

ii) Engine requirements

The model during the tests will be powered by two Engine Simulators, one on each wing. The Model Propulsion System shall enable to cope with following requirements:

a) To fit inside the engine nacelle external shape, as resulting from input CATIA surfaces;

b) To match Thrust Coefficient (CT) based on each engine simulator apparent thrust according to input data (it has suggested to consider a pitch discrete system for the blades to satisfy the thrust requirements).

The capability to set and keep thrust developed by each of the Engine Simulators within 5% of the target value is required.

All the physical parameters related to the thrust provided by each Engine Simulator shall be gathered and recorded.

Nacelles have to be designed to house sensors, kulite type, for possible acoustic measurements ([1]). The layout of the sensors will be provided in the wind tunnel model requirements report.

Outputs:

a) Engine simulator design and instrumentation, design of nacelles baseline and modified configuration(s) and of propellers **– Deliverable D1.2.1**

Note

(1) Acoustic measurements are not part of the concerned WT tests but they could be performed during a subsequent test campaign (out of the concerned project) in the frame of the GRA ITD program.

Task 1.3 - WT Model Instrumentation

Inputs:

i) Wind Tunnel Model Requirements

The model will be equipped with steady and unsteady pressure transducers. In particular, at least 150 pressure taps will be located on the model. Probes exact locations will be specified in the technical specification provided by the GRA ITD Member. Several, say 20 (twenty) kulites will be located on each nacelle in order to allow acquisition of pressure fluctuations for subsequent acoustic measurements [see Note (1) above].

The Applicant shall propose a suitable way to integrate the probes (psi, Kulites) in order to realize non-intrusive experimental measurements of the flow field around the A/C model.

At least two accelerometers measuring wing tip accelerations will be installed for test security reasons in order to prevent possible occurrence of dynamic aero-elastic instability phenomena. These transducers shall be connected to an emergency test shut down system to cut off divergence development.

Outputs:

a) Aircraft WT model Instrumentation report - **Deliverable D1.3.1**

Task 1.4 - WT Model Manufacturing

Inputs:

i) CAD files from Task 1.1

ii) CAD files from Task 1.2

The Applicant should manufacture a complete aircraft modular scaled WT model. The model scale should be not less than 1:7 (full-size full-span length ≈ 29m - Aspect Ratio ≈10.6) In particular, the following modular parts have to be manufactured:

a) Fuselage

b) T-Tail plane: Vertical Tail equipped with Rudder and Horizontal Tail equipped with Elevator

c) two half-wings equipped with winglets, trailing edge (IB & OB) Flaps, Aileron, Airbrake/Spoilers

d) two engines simulators

e) engine nacelles considering baseline configuration released by the ITD Member and alternative shape(s) proposed and designed by the Applicant.

f) propellers

Outputs:

a)Aircraft WT model (HW) - **Deliverable D1.4.1**

b)Aircraft WT model manufacturing description - **Deliverable D1.4.2;**

1.5.2 WP 2 – Wind tunnel Test Activity

Task 2.1 – Static and Dynamic Ground Vibration Tests

Input:

i) WT model (HW), Wing WT model aero-elasticity analyses (from WP1)

Prior to WT testing the A/C model will be submitted to the following tests:

1) Static vibration tests in order to check the static deformation. The results will be checked by comparison with numerical analyses.

2) Dynamic vibration tests to measure the natural frequencies of the model.

Outputs:

a) WT model static vibration tests report **– Deliverable D2.1.1**

b) WT model dynamic vibration tests report - **Deliverable D2.1.2**

Task 2.2 – Wind Tunnel Test Campaign

Inputs:

i) Aircraft WT model (HW) from WP1

The wind tunnel test campaign will be performed at low-speed regime (Mach range ≈ 0.1 - 0.2) with the aims to test the A/C model at take-off / first-climbing / descent / landing phases, in order to validate in a representative environment at high-lift conditions the aerodynamic characteristics of an advanced Turbo Prop Green Regional Aircraft configuration.

Experimental Phase

The testing phase will concern the assessment of the aircraft configuration low-speed aerodynamic performances in terms of stability and control and high-lift behaviour.

Following measurements are envisaged:

- Steady pressure measurements;
- Aerodynamic forces 6-component balance measurements to gather lift, drag, lateral force, pitching moment, roll and yaw;
- Aerodynamic loads distributions;
- Stability and control measurements.

The tests will be performed in order to assess:

a) effect of nacelles / wing integration configurations; baseline (input) geometry and at least an alternative solution (nacelle shape / installation);

b) trailing edge devices performances in high lift conditions; various flap deflections (corresponding to take-off, intermediate and landing positions) and settings (gap / overlap combinations) will have to be considered;

c) ailerons, elevator, rudder and airbrake/spoilers performances;

d) engine thrust effects;

e) ground effect with landing gears extended.

Outputs:

a)WT tests plan – **Deliverable D2.2.1**

b)WT tests report – **Deliverable D2.2.2**

c) Overall results of the A/C WTT investigation – **Deliverable D2.2.3**

1.6 Requirements

Sensitive information may be released at a later stage to the successful Applicant.

1.7 Milestones

M1 (T_0 + 4 months):
WT Model Preliminary Design Review

M2 (T_0 + 8 months):
WT Model Design

M3 (T_0 + 18 months):
WT Model manufacturing Acceptance

M4 (T_0 + 20 months):

Static and dynamic grounded vibration tests

M5 (T_0 + 21 months)
Wind Tunnel Test Plan

M6 (T_0 + 22 months)
Wind Tunnel Tests Results

Review meetings to monitor on the work progress will be scheduled likely two weeks before the expected achievement of respective milestones above. On such occasions, recovery actions will be decided, in case of delayed activities, trying to stay in the overall initial planning.

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

- Use of advanced computational tools for 3D aerodynamic (CFD) and aero-elastic/structural analyses (CFD/CSM coupling) is regarded as a paramount requirement to correctly address the physical phenomena involved.

- Large experience in designing and manufacturing of wind tunnel models for aeronautical applications

- Expertise in CATIA V5 software

- Large experience in WT tests on complete A/C model configurations. The characteristics (flow quality measurements techniques and data acquisition system) of the wind tunnel have to ensure highly-accurate measure of aerodynamic forces and moments at testing conditions (Mach, Reynolds) as above specified.

As it concerns the WT model D&M (WP 1), the availability of an advanced software environment able to trace all technical requirements, their relevant solutions, possible mismatches between requirements and solutions is seen as a key factor of innovation applicable to the project organisation and management, in order to minisime risks and reduce costs. In this context, an extensive use of virtual mock-ups and virtual testing techniques is sought as an essential element.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1.1.1	Aircraft WT model design	REPORT, CAD and FEM models	T_0 + 6 months
D1.1.2	Aircraft WT stress analysis	REPORT	T_0 + 10 months
D1.2.1	Engine simulator, nacelle and propeller models design and instrumentation	REPORT	T_0 + 10 months
D1.3.1	Aircraft WT model Instrumentation	REPORT	T_0 + 4 months
D1.4.1	Aircraft WT model	HW	T_0 + 18 months
D1.4.2	Aircraft WT model manufacturing description	REPORT WT Model Acceptance	T_0 + 19 months
D2.1.1	WT model static vibration tests	REPORT	T_0 + 20 months
D2.1.2	WT model dynamic vibration tests	REPORT	T_0 + 20 months
D2.2.1	WT tests plan	REPORT	T_0 + 21 months
D2.2.2	WT tests	TEST REPORT	T_0 + 22 months
D2.2.3	Overall results of the A/C WTT assessment	REPORT	T_0 + 24 months

4. Topic value

Budget:

2,400,000 €

(2 Million and Four Hundred Thousand Euro)

Including all cost categories (personnel, computing, travels, materials, WT tests costs, etc.);

Funding: ranging from 50% to 75% of the budget

5. Remarks

The validation of the architecture of a Turbo Prop Green Regional Aircraft in landing and take-off conditions through a large-scale powered Wind Tunnel model is thought as an essential and challenging task in order to assess the A/C aerodynamic performances in an experimental WT environment representative of low speed in-flight conditions, so as to achieve a step in the TRL.

The overall phase related to the WT experimental activity will be monitored (under control of the GRA ITD Member) according to a standard procedure. In particular, following steps / milestones are envisaged relatively to the WT model D&M process:

i) PDR to assess that requirements have been correctly addressed and relevant technical solutions identified;

ii) CDR (held at the end of the Design Development phase) to assess that the WT model design meets all technical requirements;

iii) Acceptance Review to assess that the “as built” model is such that all requirements are fulfilled and all acceptance tests are performed without still open issues.

A similar approach will apply to monitor the preparation of the WT facility (possible adaptations, experimental set-up) for the tests purpose.

Topic description

CfP No.	Title		
JTI-CS-2013-01-GRA-02-021	Highly-accurate/reliable WT test demonstration of low-noise innovative MLG configuration	**End date**	T_0 + 18 months
		Start date	T_0 (**)

Note (**): T_0 is the effective date of contract

1. Topic Description

Introduction

The objective of the activity under this CfP is the test of a full-scale Main Landing Gear fuselage-mounted architecture sized for a high-wing regional aircraft configuration in a Wind Tunnel facility.

A complete architecture shall be considered, including gear struts, wheel pack, bay cavity and doors, fairings and portion of fuselage as well as all the low-noise solutions which will be down-selected at the end of the relevant technologies development phase in the frame of the GRA ITD – LNC project.

The Applicant will design and manufacture a full-scale mock-up of the MLG integrating low-noise devices as indicated from the GRA ITD Member. The model shall be modular in order to test both the baseline and the low-noise MLG architecture with one or both gear legs. Then, the Applicant will perform aero-acoustic wind-tunnel tests on the above MLG test model installed in a proper experimental aero-acoustic facility to measure generated noise from different gear components (struts, wheels, bay, doors…) and propagated noise in far-field, and to localise noise sources by means of beamforming technique and will finally release measured data and test report.

A full-scale complete model is required, but innovative solutions of a half model with a mirror surface in the symmetry plane that enables the possibility to extrapolate the results to a complete model are also envisaged. The comparison of both solutions will be performed in wind tunnel.

Abbreviations and Definitions

A/C	Aircraft
CAA	Computaional Aero Acoustics
CFD	Computational Fluid Dynamics
CfP	Call for proposal
EPNL	Effective Perceived Noise Level
FEM	Finite Element Model
MLG	Main landing gear
OASPL	Overall Sound Pressure Level
SPL	Sound Pressure Level
WTT	Wind tunnel test

Technical Information and Project Overview

Sketch and preliminary sizing of MLG installed architecture to be considered are shown in the figures below.

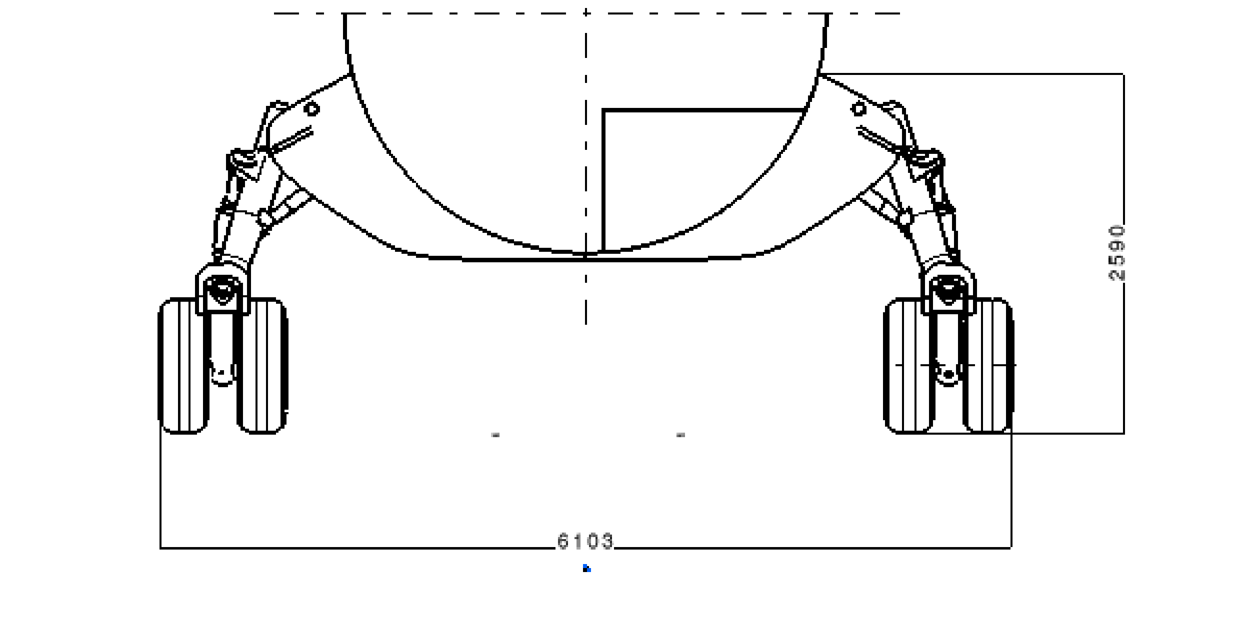


Figure 1: Expected full-scale MLG baseline geometry (dimensions in mm)

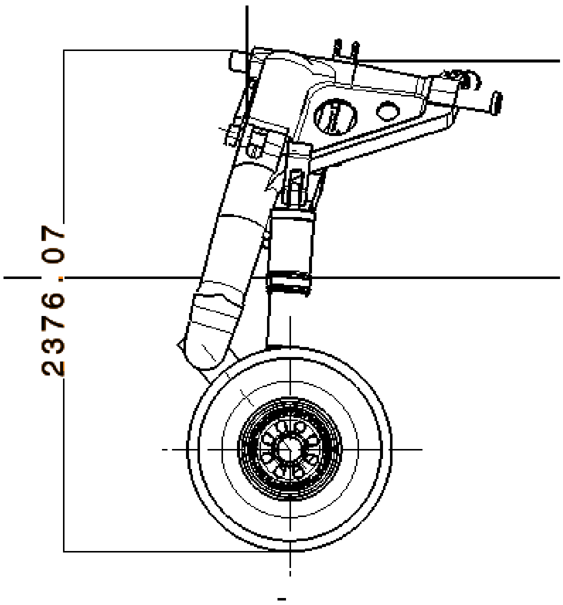


Figure 2: Full scale lateral view of MLG (dimension in mm)

The GRA member will provide the Applicant with the geometry (CAD files) of MLG and of a Technical Specification indicating model features, limitations, detailed test matrix and required measurements. Full-scale mock-up of MLG will have to be manufactured. Based on the rough sizing reported in figures 1 - 2, approximate dimensions of test model will be: ≈ 6.1 m x 2.6 m (including both left and right gears).
Aero-acoustic Wind-Tunnel Tests (flow speed up to ≈ 70 m/s) will have to be carried out to measure noise generation from different gear components and noise propagation in far-field.
According to the aforementioned work flow, the project will develop through the following tasks:
Task 1 – Main Landing Gear Design
Task 2 – Main Landing Gear Manufacturing
Task 3 – Wind Tunnel Test Campaign
Task 4 – Aero-acoustic Measurements analysis and relevant results

The wind tunnel model will include relevant noisy details such as cabling (a dressed model has to be used).

Required HW/SW

In the proposal the Applicant has to provide relevant information (including background noise level, flow quality, test section size and proposed model mounting solution, …) concerning the wind tunnel that will be used for the aero-acoustic tests. The concerned experimental facility has to be an aero-acoustic wind tunnel; the instrumentation set up (noise beamforming technique is required) has to be provided by the Applicant and Applicant's relevant expertise has to be demonstrated.

Reporting

In addition to the major project deliverables a monthly progress report has to be prepared by the Applicant in correspondence of each planned progress meeting.

Schedule

Project schedule has to be detailed by the Applicant in the relevant proposal on the basis of the following key dates:
Month 8: Critical Design Review (MLG WT model design acceptance)
Month 18: Wind tunnel tests and data analysis completion (end of the project)
GRA Members' personnel have to be allowed to participate in the Wind tunnel tests campaign.

Work Description

Task 1: Main Landing Gear Design
Starting from the reference geometry provided by the GRA ITD member, the Applicant shall build a detailed model for manufacturing issues.
The model shall contain details of gear struts, wheels, cargo bay and doors, fairings and portion of fuselage. The model shall integrate also low-noise solutions as indicated by the GRA ITD member. A PDR and a CDR will be taken for the acceptance of the model.

The model will be conceived as a modular test article, in order to:

- install only one leg or both; the objective is to study the effect of both legs in terms of interaction noise, and to replicate the interaction effect with a mirror surface in the centreline.
- test the baseline architecture and the one integrating various low-noise solutions (acoustic treatments, fairings, other devices) as specified by the GRA ITD Member.

The model will be used to perform structural static, dynamic and aero-elastic analyses, by means of FE method. A CFD/CAA model will also be built for aero-acoustic prediction of generated and transmitted noise.

Inputs:
GRA member will provide:

- CATIA V5 file of reference geometry to be used for model design;
- Sizing loading;
- Technical specification of the model, wind tunnel test matrix and measurements requirements

Outputs:

- Detailed 3D CATIA V5 file of test model geometry complete with all details necessary for manufacturing - D1.1
- Detailed 3D CATIA V5 of test model – wind tunnel interface – D1.2
- Technical report with model structural verifications, weight and balance data, assembly and configuration changes procedure, instrumentation interfaces – D1.3
- Technical Report with FEM stress analysis, modal and aero-elastic analyses – D1.4
- Technical Report with CFD/CAA aero-acoustic analysis – D1.5

Deliverable	Title	Description (if applicable)	Due date
D1.1	Detailed 3D CATIA V5 file of test model geometry complete with all details necessary for manufacturing	Drawings	
D1.2	Detailed 3D CATIA V5 of test model – wind tunnel interface	Drawings	
D1.3	MLG model structural verifications, weight and balance data, assembly and configuration changes procedure, instrumentation interfaces	Tech. Report	
D1.4	FEM stress analysis, modal and aero-elastic analyses	Tech. Report	

D1.5	CFD/CAA aero-acoustic analysis	Tech. Report	

Task 2: Main Landing Gear Manufacturing
In this task the Main Landing Gear model will be manufactured as defined in detailed design of Task 1.
Inputs:
GRA member will provide
- Manufacturing tolerances;
- Target weight;

Outputs:
- Test model hardware (D2.1)
- Technical report with Test model description and quality verification including positive checks on tolerances and target weight (D2.2)

Deliverable	Title	Description (if applicable)	Due date
D2.1	Test model hardware	Hardware	
D2.2	Test model description and quality verification including positive checks on tolerances and target weight	Technical Report	

Task 3: Wind Tunnel Test Campaign
Wind tunnel test will be performed in a Facility that is suited for aero-acoustic measurements.
A general purpose aerodynamic wind tunnel is not accepted for this test campaign.

The general dimensions of wind tunnel should be capable to host the full scale landing gear complete model, with both legs. Overall size of the MLG mock-up will be approximately ~ 6.1 m x 2.6 m.

The wind tunnel will be able to measure generated noise on different gear components and radiated noise in the far field.
A suggested high-level Test Matrix is as follows:
1. Wind Tunnel background noise @ 10 flow speed values (40 – 70 m/s range);
2. Main Landing Gear model (both left and right gear) aero-acoustic characterization @ 10 flow speed value (40 – 70 m/s range);
3. Main Landing Gear model (only left or right gear with a mirror surface) aero-acoustic characterization @ 10 flow speed values (40 – 70 m/s range);

Deliverables	Title	Description	Due date
D3.1	Wind Tunnel Test Plan		
D3.2	Wind Tunnel Test Report		

Task 4 – Aero-acoustic measurements analysis
The following measurements shall be performed:
- Far Field Noise, 15 microphone locations on a polar arc centered on MLG
- Noise Source Localization, by means of a microphone array for the Beamforming technique
- Model Vibration control, minimum number of accelerometers to control vibrations during testing.

All data shall be analyzed in order to obtain
- 1/3 Octave Band SPL, OASPL, A weighted-OASPL; at each microphone of far-field
- Emitted Noise map on model, for the identification of noise sources, in the beamforming measure
- Define noise metrics (EPNL, SEL, dBAmax, …) for the evaluation of their variation with tunnel speed.

Deliverables	Title	Description	Due date
D4.1	Acoustic characterization of far-field noise		
D4.2	Identification of noise sources, at different test speeds		
D4.3	Acoustic test analysis: effects of test speed variation on noise metrics		

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

HW/SW capabilities
Essential: Availability of aero-acoustic wind tunnel and of aero-acoustic measurements instrumentation.

Test articles requirements
MLG test article will have to be full-scale model of respective actual configuration. Therefore, expected size of the MLG test article size is about 6.1 m x 2.6 m. (front view, see figure 1 for reference), considering both left and side undercarriage. The actual landing gear geometry (CAD model) will be provided before the start of the project and will be slightly different from the one represented in figure 1.
The MLG model shall include wheels, gear bay, doors, part of belly fairing; the upper fuselage surface will be not considered. The test article has to be modular so that different configurations (both gear sides or only one with the addition of a mirror surface) can be tested. The Applicant has to describe in the Proposal a solution for a realistic representation of the landing gear components.
The Applicant has also to declare the level of detail of the test article (cables, screws, etc.) to represent MLG configuration.

Wind tunnel requirements
The wind tunnel test section must have a size sufficient to avoid blockage and wall interference effect and must be properly equipped to reduce background noise and wall noise interferences.

Tests have to be performed at 40 and 70 m/s
Expected background noise should be lower than 80 dB(A) at 40 m/s
The wind tunnel has to be equipped with microphone arrays to apply beamforming techniques and must be able to identify the location of different noise sources and their intensity.

Generic capabilities required vs. expected results
The applicant has to demonstrate skill in aero-acoustics and previous expertise on landing gear noise experimental assesment.

3. Major deliverables and schedule (see work description)

4. Topic value (€)

Budget:

1,400,000 €

(One Million and Four Hundred Thousand Euro)

Including all cost categories (personnel, computing, travels, materials, WT tests costs, etc).
Funding: ranging from 50% to 75% budget

5. Remarks

- All core RTD activities have to be performed by the organisation(s) submitting the proposal. If some subcontracting is included in the proposal the proposal must :

- indicate the tasks to be subcontracted ;
- indicate the sub-contracting partners with skill and expertise description ;
- 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)

- The expected length of the technical proposal is between 20 (min) and 60 (max) pages.

Topic Description

CfP topic number	Title			
JTI-CS-2013-1-GRA-02-022	Technological optimisation and experimental validation through an aero-servo-elastic innovative WT model of gust load alleviation control system for advanced regional aircraft	**Start date**	T_0 (**)	
		End date	T_0 + 24 months	

Note (**): T_0 is the effective date of contract

1. Topic Description

Short description

In the framework of the GRA ITD – LNC Project a NLF wing aerodynamic and aeroelastic design, integrated with Load Control and Alleviation (LC&A) devices, is under development aiming at alleviating wing loads to optimise wing structural design for weight savings and at improving aerodynamic efficiency in the whole A/C flight envelope.

Following the technology development of the LC&A system, in order to increase TRL of concept, the technological optimisation and experimental validation of Control System (Gust Load Alleviation – GLA) are needed through an aeroservoelastic scaled model wind tunnel low-speed testing (including active control laws and sensors).

General requirements for these WT tests are:

a) A/C with flexible wing WT model (wing structural dynamic behavior and characteristics properly scaled);

b) Model gust alleviation devices active;

c) Model system sensors models active in the loop with control laws;

d) Model control law engineering model in the loop with GLA devices;

e) Wind tunnel gust generator (wind tunnel air flow direction changes).

The present topic is considering the design, manufacturing and WT testing of an A/C with flexible wing and loads alleviation actuated devices model representative of the scaled structural dynamic behavior. The actuation of devices will be performed by the LC&A control laws engineering model and sensors models both in the loop with GLA devices.
WT shall be capable to simulate gusts, charactherized by different lenght and speed, by means of air flow direction changes.

WT tests shall be performed at low speed, properly scaled with model stiffness, to simulate full envelope gust design and off design conditions.

The topic objectives are as follows:

1) To validate the simulation activity performed to define the gust load alleviation strategy;

2) To verify the control law alleviation capabilities, when coupled to a real aeroelastic system during gust occurrences, simulated in WT;

3) To validate the functionality of sensors in the loop;

4) To verify the interaction and signals cTMn functionality between control laws and wing sensors in an experimental aerodynamic environment, coupled to a realistic aeroservoelastic system.

1.1 Introduction

1.1.1 Background

Within the “Low-Noise Configuration” (LNC) Project of the Green Regional Aircraft ITD, advanced wing technologies are addressed tailored to future regional airliners, by taking into account several A/C configurations and different power plant architectures. The final aim is to contribute to drastically reduce the environmental impact of regional air transport over next decades, according to the strategic road map stated in the "Vision 2020" by ACARE.

On this scenario, technology innovation is pursued along the LNC project work programme toward paramount concepts/functions for a next-generation Green Regional rear-fuselage engine A/C configuration:

i) Natural Laminar Flow wing to reduce fuel consumption and pollution at cruising flight condition;

ii) Load control to enhance wing aerodynamic efficiency in all flight phases, so as to reduce fuel consumption and gaseous emissions over the A/C whole mission profile, also allowing for steeper, noise-abatement take-off/ initial climbing trajectories;

iii) Load alleviation to avoid any possible loads exceeding over structural design point so as to optimise the wing structural design for weight savings.

1.1.2 Interfaces to ITD

The work being the subject of the present CfP is concerned with a multi-disciplinary optimization (loads, aeroelasticity, control laws) and experimental validation through WT testing of a manoeuvre and gust alleviation system for a NLF wing, integrating LC&A devices, tailored to a next-generation regional A/C configuration addressed within the Green Regional Aircraft ITD.

The input/output geometrical models data exchange will be handled through standard formats (IGES, CATIA, NASTRAN, MATLAB). The wind tunnel output data will be handled through technical reports and standard format on DVD.

1.2 Scope of work

Topics and expected outcomes of the activity inherent to the present Call for Proposals are dealing with:

i) Optimisation of Loads Alleviation control system concept applied to a high aspect ratio transonic NLF wing configuration.

ii) Experimental validation through WT aero-servo-elastic testing at low-speed (up to 50 m/s) of LC&A system (control laws and devices) effectiveness for design and off-design conditions. Aim of such tests is to assess the viability of the system concept, thus validating the active control law and sensors system response coupled with the wing structural response under gust excitation.

Therefore a WT model of half A/C configuration equipped with a flexible wing shall be manufactured so as to reproduce not only the wing shaping but also its expected stiffness and dynamic response of wing and A/C symmetric rigid modes. A/C model scale shall be not less than 1:8 (full-size half-wing span ≈ 17m). Wind Tunnel facility shall be able to simulate different gusts (length and speed).

1.3 Type of work

Wing aerodynamic analysis (CFD), structural modelling (FEM), structural/aero-mechanics analysis (aerodynamic and loads), static and dynamic aeroelasticity analyses, control laws design and optimization, aero-servo-elastic simulation, mechanical design, wind tunnel testing and experimental data acquisition.

1.4 Abbreviations & Definitions

A/C	Aircraft
ACARE	Advisory Council for Aerospace Research in Europe
CAD	Computer Aided Design
CDR	Critical Design Review
CFD	Computational Fluid Dynamics
CfP	Call for Proposals
CL	Control Law
CSM	Computational Structural Mechanics
D&M	Design & Manufacturing
FEM	Finite Element Model

GLA	Gust Load Alleviation
GRA	Green Regional Aircraft
GVT	Ground Vibration Test
HW	Hardware
ITD	Integrated Technology Demonstrator
LA	Load Alleviation
LC&A	Load Control & Alleviation
LNC	Low Noise Configuration
Mach	Mach number
NLF	Natural Laminar Flow
PDR	Preliminary Design Review
SW	Software
TRL	Technology Readiness Level
WP	Work Package
WT	Wind Tunnel
WTT	Wind Tunnel Tests
3D	Three-Dimensional

1.5 Description of Work

According to the objectives described in par. 1.2, the concerned activity will develop through several work packages as described hereinafter.

1.5.1 WP 1 – Optimisation of Load Alleviation System control laws

Input: Full-scale A/C configuration geometry (CAD) including configurations of LC&A devices from the concepts under study within the GRA ITD, aero-elastic wing model (Nastran), engineering models (MatLab) of LC&A control laws and sensors, technical specification for WT testing.

Task 1.1

The first phase of the required work will be dealing with an optimisation of loads alleviation control laws in several flight conditions. The objective is to find optimal response, in order to enhance manoeuvre and gust wing load alleviation level in the design and off-design conditions. An initial configuration of such devices in terms of position, size & setting will be provided by the GRA ITD member; as an example, see figure 1.

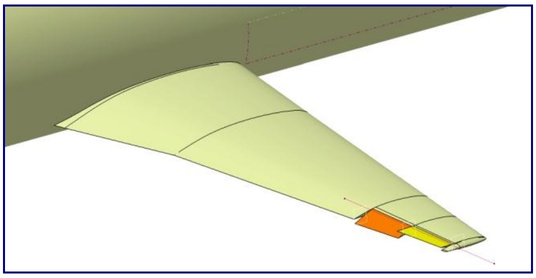


Figure 1 – Sketch of possible Loads Alleviation devices

The Applicant should optimize the LA system response for several flow and gust conditions without modifying neither the wing aerodynamic shape nor the FEM model or control law architecture/concept, but taking account of the provided wing aeroelastic behaviour. The real scale flow conditions are expected to range between Mach number [0.4 - 0.8], incidence angle [-2.5 / +2.5 deg], flight altitudes from sea level to 35 kft.

Task 1.2

The Applicant should propose and develop alternative control laws for loads alleviation, at the same design conditions as the ones considered in Task 1.1 and, hence, compare relevant performances with those achieved through initial LC&A CL configurations. The best solution(s) to be brought, together with those derived from Task 1.1, to the subsequent WT testing will be selected during a joint meeting between the GRA ITD member and the winner Applicant during task work development.

Outputs:

a) LA system optimised engineering model (CL, sensors) as proposed by ITD (MatLab/Simulink models), **Deliverable D1.1**
b) Assessment of performances of optimised LC&A system (ITD) - **Deliverable D1.2**
c) LA system engineering model (CL, sensors) as proposed by the Applicant (MATLAB/Simulink models) - **Deliverable D1.3**
d) Assessment of performances of LC&A system (Applicant) - **Deliverable D1.4**

1.5.2 WP 2 – WT Model and control system design & manufacturing

Inputs:

- Full-scale A/C configuration and laminar wing geometry, aero-elastic wing model, selected LC&A devices from WP1, wing fuel mass distributions, sensors types and locations, engineering models of CL and sensors, technical specification for WT testing.

The mathematical model related to full-size aeroelastic laminar wing equipped with the selected LC&A devices (from WP 1) and the considered “rigid” A/C tail (half A/C) has to be scaled down to the wing tunnel model size. Maximum A/C scale reduction allowed is 1:8 with respect to full scale.

Wing scaled mathematical model (stiffness and mass distributions) should be appropriately designed to be representative of full-scale wing dynamic response, for several internal fuel configurations, reproducing correctly scaled reduced frequencies.

Mechanical design and stress analysis for the estimation of the wing model deformation and dynamic response have to be carried out in a closed loop, because any change in the inner structural features of the wind tunnel model (due, for example, to location of sensors, cables, etc.), may strongly affect the mass distribution and inertia. In doing so, it has to be taken into account, in particular, that the WT model has to house all equipment and devices related to LA tests. Obviously wing LC&A movables and tail (elevator) surfaces shall be controlled by control laws and the respective deflection angles performed during test run shall be recorded as well.

LA control laws engineering models and sensors parameters (Gains, filters, etc) shall be properly modified to be correctly coupled with the scaled model, but without changing the original system architecture selected for the test from WP1.

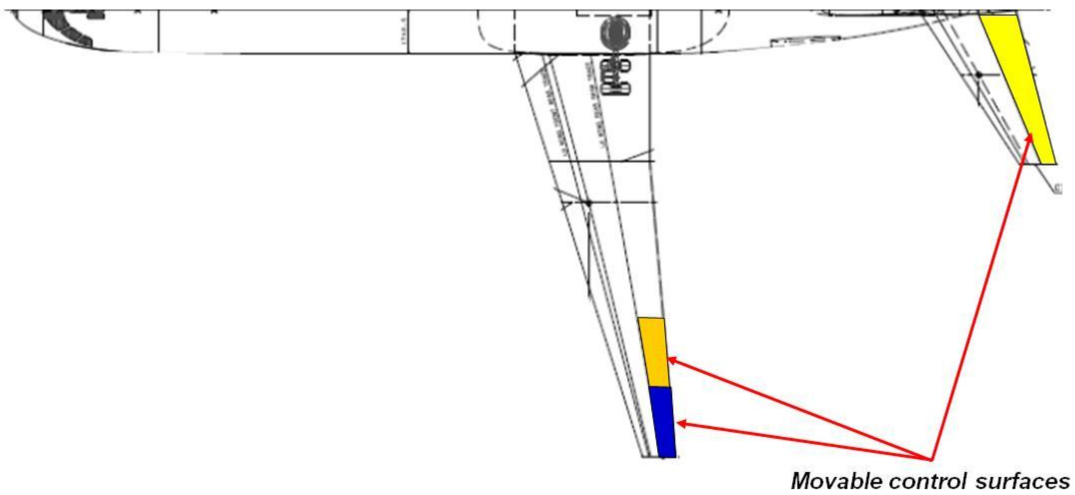


Figure 2 – Sketch of model configuration to be considered for WTT.

Task 2.1

The applicant shall design a WTT model equipped with instrumentation devices able to perform the following measurements:

Displacements

During the test phase, the capability to measure wing model steady and unsteady displacement is mandatory, in particular:

- Vertical displacements (orthogonal to wing plane), bending rotations, twist rotations pertinent to at least 10 sections along the wing span shall be monitored.
- Total A/C model displacements (heave and pitch) measurements is also required

Accelerometers

- Accelerometers will be placed along the wing span in at least 10 sections and on LC&A devices to gather wing structural dynamic response.
- At least two additional accelerometers measuring (in real time) wing tip accelerations will be present for test security reasons in order to prevent possible occurrence of dynamic aero-elastic instability phenomena during test. These additional transducers shall be connected to an emergency test shut down system to cut off divergence development.

Loads measurements

- During test wing loading (several wing sections and hinge moments) measurement capability is mandatory.
- Wing loads monitoring sections (at least 10) along span and total half A/C load (for reference only) measurement shall gather Vertical Force, Torsion (Pitching) and Bending (Roll) Moments.
- Some loads strain gauges bridges (real time working) shall be properly installed on wing in order to aid the emergency accelerometers work (see previous point). The position and number of these shall be defined by the Applicant during the model design phase.
- Wing loading will be complemented by control surfaces direct hinge moments measurements.
- Monitoring of wing movables deflections and actuation rate shall be necessary.

The emergency accelerometers and loads measurements are requested to be performed in real time. Both transducers shall be connected to an emergency test shut down system to cut off possible divergence development during wind tunnel test.

The active control surfaces configurations shall be those indicated in Figure 2: two independent aileron sections and elevator.

Control laws probes and sensors exact locations will be specified in the technical specification provided by the GRA ITD member.

As a whole, the WT model has to be designed and manufactured so as to perform following WT tests:

1) Steady flight conditions for the clean wing (nominal shape) (*);
2) Steady flight conditions for fixed LA devices deflections (*);
3) Dynamic conditions (gust) for the clean wing, open loop (nominal shape, LA not active);
4) Dynamic conditions with LA system active, closed loop.

(*) for model response check

Outputs:

a) WT model design (CAD and FEM Nastran model) – **Deliverable D2.1**

b) WT flexible model description and analysis report (stress, structural dynamics, static/dynamic aeroelasticity) – **Deliverable D2.2**

c) WT model (HW) – **Deliverable D2.3**

d) WT model acceptance report - **Deliverable D2.4**

1.5.3 WP 3 – Wind Tunnel gust generator design and manufacturing

Inputs: WT technical specification for WT testing.

The discrete gust simulations shall be performed by means of a dynamic variation of air flow direction, simulating a gust occurrence. The gusts shall be tuned to the model structural response modes. Several discrete gust shapes and speeds shall be tested following the requirements provided by the ITD. The gust generator system shall be supplied and eventually designed and manufactured by the Applicant. In case of modification of an existing system or design of a new system, the Applicant shall supply evidence of the adopted design criteria and of experimental performance of the system. Evidence of system performances shall be provided also in case of an existing system. This deliverable shall be one of input documents for the Acceptance Review of the Applicant's laboratory together with instrumentation specification and performance evidences.

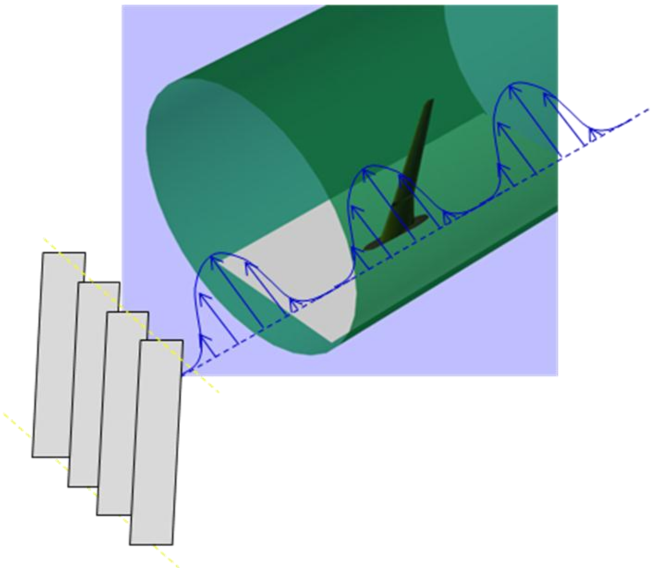


Figure 3 – Sketch of a possible gust generator configuration for large-scale WTT.

Outputs:

a) Gust generator system design report - **Deliverable D3.1**

b) Laboratory performance acceptance report – **Deliverable D3.2**

1.5.4 WP 4 - Static Checks and Ground Vibration Tests

Input:

WT model (HW), WT static and modal analysis results (from WP2), technical specification for WT testing.

Prior to WT testing the WT model will be submitted to following tests:

- Static Checks in order to assess/measure the bending/torsion stiffness of the WT model. Results shall be used for a first updating of the mathematical model stiffness.

- Ground Vibration Tests (GVT) aimed at measuring the modal characteristics (resonance frequencies, structural damping, modal shapes, etc.) of the WT model. Measured data shall be used to update the aeroelastic mathematical model and to perform WT test theoretical predictions.

Outputs:

a) WT model ground testing plan - **Deliverable D4.1**

a) WT model static tests report – **Deliverable D4.2**

b) WT model GVT report - **Deliverable D4.3**

1.5.5 WP 5 – Wind Tunnel Tests

Input: WT model (SW and HW) from WP1 and WP2, technical specification for WT testing.

The wind tunnel test campaign will be performed at low speed regime (max air speed 50 m/s) in order to validate the aero-servo-elastic response of LA system under gust and/or load alleviation system excitation.

The concerned tests will be split into following phases:

Phase #1

Assessment of LA ITD control system wing aeroelastic static and dynamic response for simulated gust excitation.

Following measurements are envisaged (see also paragraph 1.5.2):

- airframe local deformations (displacements and rotations) at selected points (at least 10);
- airframe local accelerations at selected points (at least 10);
- airframe sectional loads (Shear, Bending and Torque Moments) at selected sections (at least 10).

The above measurements shall be performed with LA system active and not active.

Phase #2

Assessment of LA Applicant control system wing aeroelastic static and dynamic response for simulated gust excitation.

Following measurements are envisaged (see also paragraph 1.5.2):

- airframe local deformations (displacements and rotations) at selected points (at least 10);
- airframe local accelerations at selected points (at least 10);
- airframe sectional loads (Shear, Bending and Torque Moments) at selected sections (at least 10).

The above measurements shall be performed with LA system active.

Furthermore, during LC&A devices performance tests remote monitoring and control of wing movables deflections is thought necessary.

Outputs:

a) WT tests plan (**Deliverable D5.1**)

b) WT tests report (**Deliverable D5.2**)

1.5.6 WP6 - Assessment of Project Results

Inputs:

a) Theoretical evaluation at design and off-design conditions of:

i) LC&A CL design;

ii) flexible wing structural response, LC&A devices loads alleviation performances (from WP1).

b) WT tests results from WP4

Analysis of WT tests results, extrapolation to in-flight condition, correlation with numerical predictions, problems encountered, lessons learned, comprhensive evaluation of project achievements.

Outputs:

a) WT test results extrapolation to flight and numerical/experimental correlation – **Deliverable 6.1**

b) Overall assessment of project results – **Deliverable D6.2**

1.6 Requirements

Sensitive information may be released at a later stage to the successful Applicant.

1.7 Milestones

M1 (T_0 + 7 months):
Selection of LC&A CL concepts

M2 (T_0 + 8 months):
WT Model and Laboratory Preliminary Design Review

M3 (T_0 + 16 months):
WT Model Critical Design Review

M4 (T_0 + 16 months):
WT Laboratory Critical Design Review

M5 (T_0 + 18 months)
Test Plans: Static Check, GVT, WTT

M6 (T_0 + 20 months):
WT Model manufacturing Acceptance

M7 (T_0 + 20 months):
WT Laboratory Acceptance

M8 (T_0 + 21 months)
Static check and GVT, aeroelastic mathematical model updating

M9 (T_0 + 23 months)
WT Tests and Results

M10 (T_0 + 24 months)
Overall assessment of project results

Review meetings will be scheduled likely two weeks before the expected achievement of respective milestones above. On such occasions, recovery actions will be decided, in case of delayed activities, trying to stay in the overall initial planning. Monthly techical regular meetings between Applicant and ITD to monitor on the work progress will be adopted as a practice.

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

- Use of advanced computational tools for 3D aerodynamic (CFD), aeroelastic/structural analyses (CFD/CSM coupling), control law design and simuation is regarded as a paramount requirement to correctly address the physical phenomena involved.
- Large experience in designing and manufacturing of wind tunnel models for aeronautical applications
- Expertise in CATIA V5, Matlab, Nastran software
- Good experience in GVT and stress tests. Tha availability of a reliable test layout (accelerometers, straingauges, GVT shakers, acquisition systems, etc.) and accurate measurements have to be guaranteed.
- Large experience in WT tests on aeroelastic wing models. In particular, the characteristics (experimental measurements techniques) of the WT have to ensure highly-accurate testing of wing aero-servo-elastic dynamic response under gust excitation as above specified.
- As it concerns the WT model D&M (WP2), the availability of an advanced software environment able to trace all technical requirements, their relevant solutions, possible mismatches between requirements and solutions is seen as a key factor of innovation applicable to the project organisation and management, in order to minisime risks and reduce costs. In this context, an extensive use of virtual mock-ups and virtual testing techniques is sought as an essential element.

3. Major Deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1.1	LA system optimised engineering model (CL, sensors)	(MATLAB/Simulink models)	T_0 + 3 months
D1.2	Assessment of performances of ITD optimised LC&A system	REPORT	T_0 + 3 months
D1.3	LA system engineering model (CL, sensors) as proposed by the Applicant	(MATLAB/Simulink models)	T_0 + 7 months
D1.4	Assessment of performances of new LA system	REPORT Comparison with the system performances of the 1st group of LC&A CL and choice of technical solutions for WTT	T_0 + 7 months
D2.1	WT model design	CAD and FEM models	T_0 + 16 months
D2.2	WT flexible model description and analysis report (stress, structural dynamics, static/dynamic aeroelasticity)	REPORT Critical Design Review	T_0 + 16 months
D2.3	WT and controls models	HW & SW	T_0 + 20 months
D2.4	WT model manufacturing description	REPORT Model Acceptance	T_0 + 20 months
D3.1	Gust generator system design report	REPORT Critical Design Review	T_0 + 16 months
D3.2	WT system acceptance report	REPORT Laboratory Acceptance	T_0 + 20 months
D4.1	Ground tests plan	REPORT	T_0 + 18 months
D4.2	WT model static testing	REPORT	T_0 + 21 months
D4.3	WT model GVT	REPORT	T_0 + 21 months
D5.1	WT tests plan	REPORT	T_0 + 18 months
D5.2	WT testing	TEST REPORT	T_0 + 22 months
D6.1	Analysis of WT tests results	REPORT	T_0 + 23 months
D6.2	Overall assessment of project achievements	REPORT	T_0 + 24 months

4. Topic value

Budget:

2,400,000 €

(Two Million and Four Hundred Thousand Euro)

including all cost categories (personnel, computing, travels, materials, WT tests costs, etc).

Funding: ranging from 50% to 75% budget

5. Remarks

The experimental validation of Natural Laminar Flow and LC&A loads alleviation integrated technologies through a single WT wing flexible model, reproducing the actual A/C dynamic and structural response under gust dynamic loads, is thought as a very innovative and challenging task. This, indeed, is considered as an essential requirement for the assessment of the concerned technologies in a WT environment representative of the in-flight conditions, so as to achieve a step in the TRL.

The overall phase related to the WT experimental activity will be monitored (under control of the GRA member) according to a standard procedure. In particular, following steps / milestones are envisaged relatively to the WT model D&M process:

i) PDR to assess that requirements have been correctly addressed and relevant technical solutions identified;

ii) CDR (held at the end of the Design Development phase) to assess that the WT model design and possible adaptations, experimental set-up of laboratory meet all technical requirements;

iii) Acceptance Review to assess that the “as built” model and laboratory eventual modifications are such that all requirements are fulfilled and all acceptance tests are performed without still open issues.

Topic Description

CfP topic number	Title		
JTI-CS-2013-1-GRA-02-023	Development of methodology for structural and mechanical analysis on kinematics and actuators integration for aircraft high lift devices and load, control & alleviation devices	**End date**	$T_0 + 10$
		Start date	T_0

1. Topic Description

1.1 – Scope of work

The scope of work of the topic is about the optimization of Load Control & Alleviation innovative technologies and High Lift Devices highly efficient technologies developed for the GRA 130-seat and 90-seat aircraft configurations, chosen for the integrated technologies demonstration phase within the GRA ITD.

The optimization concerning the current topic is focused on the innovative mechanical implementation of both the HLD and the LC&A technologies into both aircraft configurations.

The task to be implemented is comprised into the following subtasks:

a. Load control and alleviation devices (LC&A).

LC&A devices implemented into the Natural Laminar Flow (NLF) wing, concerning innovative rear-mounted geared turbo-fan twin engine 130-seat aircraft configuration.

The purpose of this subtask is the development of structural and mechanical concept analysis in order to define corresponding substructures, so as kinematics and actuators integration for aircraft wing LC&A devices sections to be implemented to the innovative aforementioned aircraft. Full CAD & FEM models shall be produced. Analysis shall be based upon aero-structural and actuation requirements already defined.

The activity shall be performed in two steps:

- Definition of LC&A devices' CAD models, including definition of kinematics and actuation integration.
- Based on existing innovative CAD modelling, structural integration of LC&A devices actuation solutions, definition of FEM models including final structural sizing of kinematics and structural integration into the aircraft wing.

This subtask shall be performed in concurrence with actuation rig specification.

b. High lift devices

High lift devices attached into Natural Laminar Flow (NLF) wing, concerning the innovative rear-mounted geared turbo-fan twin engine 130-seat aircraft configuration.

The purpose of the subtask is the development of an actuation/ kinematic system concept for leading edge (L/E) and trailing edge (T/E) high-lift devices (HLD) architectures that shall be explicitly defined. Design and integration of other equipment, sub-components, and low-noise innovative solutions shall also be engineered.

High lift devices architectures to be considered:

- Krueger Flap

On the basis of preliminary studies on feasible mechanisms, definition of kinematics and actuation solution of the aforementioned L/E device by considering both on-board systems items and structural sub-components; input data will be an existing 3D CAD model of the wing high-lift configuration and relevant aerodynamic loads.

- T/E Single-Slotted Flap

On the basis of the kinematic concept studies performed on the full-Fowler T/E flap, definition of kinematics and actuation solution of the T/E device by considering both on-board systems items and structural sub-components including flap tracks fairings; input data will be an existing 3D CAD model of the wing high-lift configuration and relevant aerodynamic loads.

c. High lift devices

High lift devices attached into standard wing, concerning turboprop twin engine 90-seat aircraft configuration.

The purpose of this subtask is the development of an innovative actuation/ kinematic system concept T/E high-lift devices architectures. Design and integration of other equipment, sub-components, and low-noise solutions shall also be engineered.

The HLD device to be considered is a T/E Single-Slotted flap.

On the basis of preliminary kinematic concept studies definition of kinematics and actuation solution of the T/E device by considering both on-board systems items and structural sub-components including flap tracks fairings; input data will be a 3D CAD model of the wing high-lift configuration and of corresponding geometry of the optimised setting, as well as relevant aerodynamic loads.

Results of intermediate studies on structural sizing of several sub-components shall be produced in order to support the design of the T/E device kinematic / actuation system. Full CAD and FEM models shall be created and engineered.

A detailed conceptual design of the deployment mechanism shall be engineered and produced. Furthermore, the structural sizing of the integration solutions of the T/E device and relevant actuation/ kinematic system components shall be defined, followed by full and complete CAD and FEM models.

d. Technology Transfer

For all above mentioned activities (i.e. kinematics, actuation, CAD models, FEM models, design etc.) full tool-level and on-the-job guidance shall be provided to two (2) TM's dipl. Engineers, upon TM's request.

1.2 – Reference documents

Corresponding scientific and industrial bibliography.

Detailed CAD drawings and initial concepts shall be handed over from TM to the contractor whenever necessary.

1.3 – Introduction

In order to achieve the project's prerequisite of low-speed aerodynamic performance, a detailed kinematic design of the HLDs and LC&As are necessary so as to meet the surfaces excursions as required by the aerodynamic design adopted in project.

Kinematic conceptual design shall be performed to:

1. Double Slotted Fowler flap
2. Krueger slat
3. Single-slotted (full-Fowler type) T/E flap
4. Single slotted T/E flap (Turbo prop 90-seat configuration)

Innovative flap side-edge fences shall be taken into consideration during design, analysis and engineering.

LC&A conceptual design shall be performed on devices that shall be disclosed whenever necessary.

The partner shall analyse each HLD and/or LC&A device based upon corresponding theory as applied on documented motion. For example, Fowler motion is defined as:

$$FM_{TE} = (X_1 + X_2)/C_W \times 100(\%)$$

Where FM_{TE} is the flap Fowler motion, X_1 is the first flap element translation in the chord plane of the wing, X_2 is the second element translation in the chord plane of the first element and C_W is the basic wing chord.

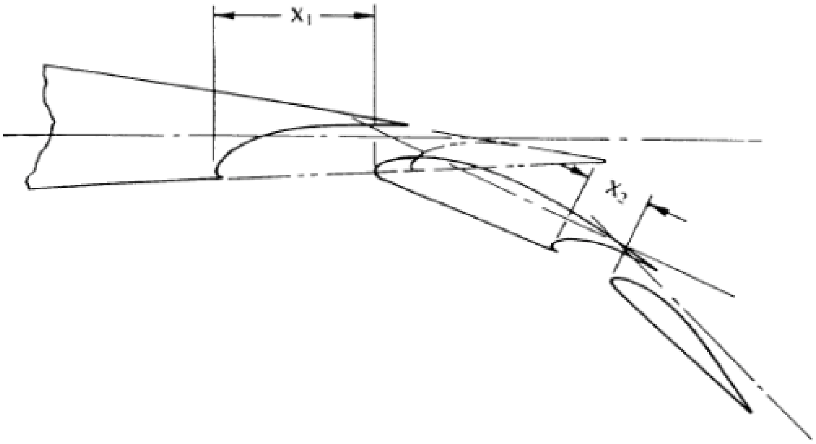


Image 1: Trailing-edge double-slotted flap Fowler motion

The main types of mechanisms used on most aircraft to actuate the double-slotted Fowler flap surfaces are the following:

- Three types of simple four-bar linkage: upright, upside-down and upside-down/upright
- Several mechanisms of complex four-bar linkage
- Several variations of hooked tracks
- Various versions of link/ straight track mechanisms

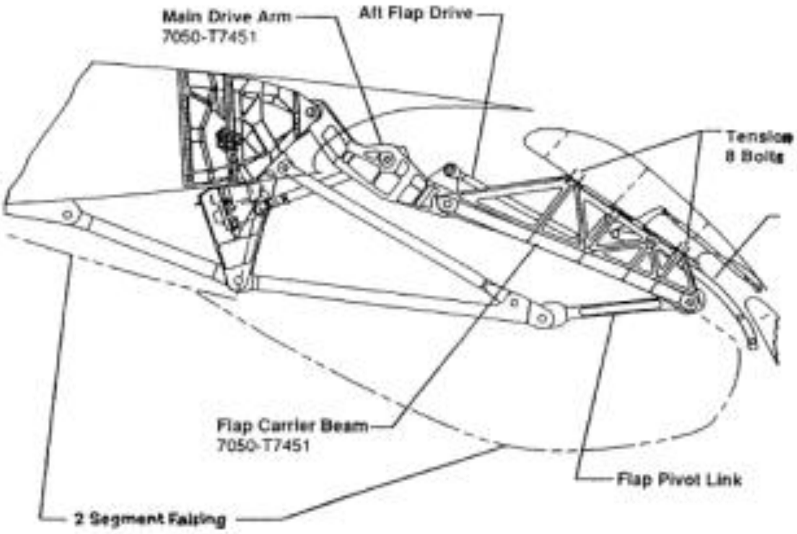


Image 2: Four-bar linkage

The partner must be highly familiar with such concepts.

1.3.1 – Interfaces to ITD

The activities of the present Call for Proposal are part of the WP 2.3.1 and WP 2.3.2 of the GRA-2 ITD.

A kick-off meeting will be held at the beginning of the project object of this call in order to (i) decide how to manage the data exchange during the project, (ii) decide about knowledge-transfer details.

1.4 - Activity Description

Partner's responsibility shall be as follows:

1. All kinematics and FEM models shall be implemented based on corresponding input that shall be given from TM. Those models, shall integrate mechanical components, hydraulics, actuators and control systems technologies so as to build and test virtual prototypes that accurately account for the interactions between these subsystems. The loading scheme (static & fatigue) will be decided by TM in cooperation with the contractor.

2. The contractor shall perform full design, kinematic and derived FEM load analysis to High Lift and Load Control & Alleviation devices based on data provided by TM, which shall include but will not be limited to:
   - Krueger slat
   - Single slotted flap (Full Fowler motion)
   - Double slotted flap
   - Morphing flap
   - Droop nose
3. Aforementioned prototypes shall be designed and engineered from the contractor using tools and equipment of his preference, at his own premises. Contractor is highly encouraged to use CATIA v.5, NASTRAN, PATRAN, SimXpert Motion and MD Adams. No equipment or tools of TM shall be used.
4. All models and corresponding design must be feasible and must be designed in a way that can be manufactured and installed in real aircraft.
5. The contractor shall produce corresponding detailed report on each and every concept of kinematics and/or FEM analysis that shall be performed. During the design and the engineering of all models, the contractor shall be in continuous co-operation and interaction with TM.
6. All the derived models, FEM analysis, CAD designs, kinematics engineering reports as well as the totality of the deliverables to TM, shall be given in full editable form. For example, documents shall be delivered in full-editable word file, not pdf form. CAD models shall be delivered in full-editable form, for example .CATIApart or .CATIAassemply files, not .igs or jpg files. MD Adams files (if tool is used) shall be delivered fully functional editable form. TM preserves the right to request any other form of file – for example mp4 file of motion demonstration: Contractor shall be obliged to transform corresponding file to the one requested as long as this is technically feasible.
6. All deliverables, reports, conclusions, drawings, models, etc. shall be joint intellectual property of Topic Manager. The TM reserves the right to use them, modify them or distribute them at its own will, without any further liability to the contractor, as per corresponding EU norms applicable.
7. Results, reports, designs, analysis, and CAD and FEM models are confidential as per corresponding EU norms. The contractor shall not transmit, communicate, replicate or deliver them to any organization, institution, industry, company, etc. without the written permission of TM. A non-disclosure agreement shall be signed between TM and the contractor in full compliance with corresponding EU norms applicable herein.
8. The contractor shall be entitled to offer to two (2) dipl. Engineers of TM corresponding knowledge transfer of the procedures, the methods and the tools that shall be used. Contractor may outsource tools' training, however he must perform on-the-job guidance based on the work that shall be performed as described herein.

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

The Partner that will undertake aformentioned activities must be organised according to applicable ISO and must be equipped with the appropriate hardware, tools and software.

The Partner must possess:

- Deep and documented experience in design, analysis, engineering and implementation of mechanisms and actuators.
- Expertise in multidiscipline multibody dynamics.
- Experience in FEM stress analysis.
- Experience in design and implementation of aircraft components is highly desirable but not a strict prerequisite.
- Experience in knowledge-tranfer procedures and guidance is desirable but not a prerequisite.
- Nominees shall disclose the tools that they plan to use. Nominees that will use one or more of the following tools shall be given priority during selection procedure: CATIA v5, NASTRAN, PATRAN, SimXpert Motion and MD Adams.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
CfP 2.3.1-03	LC&A devices mechanical design and integration	• Definition of LC&A devices CAD models, including definition of kinematics and actuation integration. • Structural integration of LC&A devices actuation solutions, definition of FEM models including final structural sizing of kinematics and structural integration.	T0+5
CfP 2.3.1-06	Geared turbofan (GTF) A/C Krueger flap actuation system structural design	• Krueger Flap Definition of kinematics and actuation solution of the L/E device by considering both on-board systems items and structural sub-components; input data will be the 3D CAD model of the wing high-lift configuration and relevant aerodynamic loads	T0+7
CfP 2.3.1-07	GTF A/C T/E flap actuation system structural design	• T/E Single-Slotted Flap On the basis of the kinematic concept studies performed on the full-Fowler T/E flap, definition of kinematics and actuation solution of the T/E device by considering both on-board systems items and structural sub-components including flap tracks fairings; input data will be the 3D CAD model of the wing high-lift configuration and relevant aerodynamic loads Detailed conceptual design of deployment mechanism. Structural sizing of integration solutions of T/E device and relevant actuation / kinematic system components – CAD and FEM models Preliminary definition of the anti-icing system by taking into account Krueger flap installation constraints.	T0+7
CfP 2.3.1-03_A	LC&A devices detailed mechanical design and integration	Definition of detailed structural CAD of integration solutions of wing movable devices and actuation / kinematic system components - CAD models. Final integration of LC&A devices and detailed structural sizing and final FEM models of actuation concepts and stress analysis results - FEM models.	T0+8
CfP 2.3.2-01	Turboprop A/C T/E flap actuation system structural design	• T/E Single-Slotted Flap On the basis of preliminary kinematic concept studies, definition of kinematics and actuation solution of the T/E device by considering both on-board systems items and structural sub-components including flap tracks fairings; input data will be the 3D CAD model of the wing high-lift configuration and of corresponding geometry of the optimized setting as well as relevant aerodynamic loads	T0+10

4. Topic value

Max Budget:

220,000 €

(Two Hundred and Twenty Thousand Euro)

including all cost categories (personnel, computing, travels, materials, WT tests costs, etc).

Funding: ranging from 50% to 75% budget

5. Remarks

During the period allocated for the CfP, it is possible that additional information/ requirements are given to the partner. The partner shall therefore adjust accordingly and embody the given information / requirements, prior to final deliverable.

Clean Sky – Green Rotorcraft

Identification	ITD - AREA - TOPIC	topics	VALUE (€)	MAX FUND (€)
JTI-CS-GRC	**Clean Sky - Green Rotorcraft**	**4**	**2,720,000**	**2,040,000**
JTI-CS-GRC-01	*Area-01 - Innovative Rotor Blades*		**320,000**	
JTI-CS-2013-01-GRC-01-014	Development and Testing of Computational Methods to Simulate Helicopter Rotors with Active Gurney Flap		320,000	
JTI-CS-GRC-02	*Area-02 - Reduced Drag of rotorcraft*		**900,000**	
JTI-CS-2013-01-GRC-02-016	Assessment of optimized tiltrotor engine intake performance by wind tunnel tests		450,000	
JTI-CS-2013-01-GRC-02-017	Contribution to the aerodynamic design of a helicopter air intake through wind tunnel testing		450,000	
JTI-CS-GRC-03	*Area-03 - Integration of innovative electrical systems*			
JTI-CS-GRC-04	*Area-04 - Installation of diesel engines on light helicopters*			
JTI-CS-GRC-05	*Area-05 - Environmentally friendly flight paths*		**1,500,000**	
JTI-CS-2013-01-GRC-05-008	Innovative measurement and monitoring system for accurate on-board acoustic predictions during rotorcraft approaches and departures		1,500,000	
JTI-CS-GRC-06	*Area-06 - Eco Design for Rotorcraft*			

Topic Description

CfP topic number	Title		
JTI-CS-2013-01-GRC-01-014	*Development and Testing of Computational Methods to Simulate Helicopter Rotors with Active Gurney Flap*	**End date**	T0+36 M
		Start date	T0

1. Topic Description

Background

The Green Rotorcraft Consortium (GRC 1) work described here relates to the development of Active Rotor Technologies (ART) that will enable a helicopter to operate with reduced power consumption or reduced main rotor tip speed whilst preserving current flight performance capabilities, especially in terms of retreating blade stall. Lower power consumption will lead to reduced fuel usage and exhaust emissions, while reduced main rotor speed will significantly reduce rotor noise.

Prior tasks have evaluated a range of potential technologies that could be incorporated within active segments of a helicopter main rotor blade to meet these needs and concluded that a variable height or 'Active Gurney Flap' (AGF) offers the best overall potential. Conventionally a Gurney Flap is a small 'wall' perpendicular to the surface of the aerofoil and located in the trailing edge area of the blade, more usually on the lower blade surface. The AGF is essentially a Gurney flap with the ability to alter its height from zero (fully retracted) to maximum (fully operative). Its impact upon the performance of an aerofoil can thus be varied and controlled. On a helicopter rotor blade the aerodynamic requirements change as the blade moves around the azimuth from the blade advancing to blade retreating condition. The AGF offers the possibility of 'conditioning' the performance of the rotor blades to match these changing requirements by using a pre-determined schedule of operation (i.e. progressively extended/retracted) as the blade rotates around the helicopter.

In order to assess the capabilities of an AGF system it is intended that system demonstrators be manufactured, trialled and evaluated. A number of wind tunnel tests are planned to take place along with a full scale whirl tower test. The first wind tunnel test is in the 2D tunnel at a European University facility in 2013 (following the present work-plan). The second 2D tunnel test is at a European research centre facility in 2014, whilst a 3D model rotor test is planned for a large wind tunnel facility in 2014. Finally, the full scale whirl tower test is planned in 2015. These tests are important for evaluating AGF performance but also to validate the Computational Fluid Dynamics (CFD) tools and numerical methods in general.

The applicant has to select the most appropriate CFD tool suitable for this programme and should demonstrate a dedicated methodology to simulate AGF deployment on both 2D airfoils and 3D helicopter rotors. This capable tool must be validated against a large suite of available test data (that will be acquired as explained before during several 2D and 3D Wind Tunnel test entries and Whirl Tower tests) on standard rotor blade configurations to prove the level of correlation. Simulations with CFD of full-scale rotors in forward flights with AGF to enhance helicopter performance and reduce aeroacoustic footprints are furthermore needed to be produced in the course of this work. The latter will be assumed to be 'blind-cases' for a possible future flight tests campaign.

To achieve these aims the Green Rotorcraft Consortium request bids from companies or consortiums to carry out the required development and validation of the CFD software against all sets of wind tunnel and whirl tower data, and provide CFD predictions of AGF performance in the forward flight conditions supplied by the Topic Manager.

Scope of work

In order to satisfy the requirements for testing GRC Innovative Rotor Blades technologies, the Green Rotorcraft Consortium members wish to engage with an organisation (or consortium) that can validate their proposed CFD software. The work required from the successful organisation is:

a) Make any modifications necessary to the CFD software proposed by the applicant in order to provide a capability for modelling the actual deployment method used in each test.

b) Must provide source code for the parts that have been modified (if any) and a full documentation including code description, solver method, user guides and training in running the simulations. All Input/output files for simulation cases must be provided in any case.

c) Use the above software to simulate 2D and 3D wind tunnel test cases and compare results with available wind tunnel test data, and so far as is practicable provide innovative corrections to steady and unsteady free-air forces and moments.

d) Use the above software to simulate full scale rotor whirl tower test cases and compare results with available test data.

e) Perform full-scale rotor forward flight performance simulations using the CFD software for 'blind' test conditions at various points in the level flight envelope with use of AGF. These will consist of a minimum of nine initial cases and a minimum of nine subsequent test cases covering a range of forward flight conditions and AGF deployment options, as specified by the Topic Manager.

Main required characteristics of the CFD Software

It is essential that the CFD solver identified has a proven capability in simulating rotor performance. The CFD solver must be a general-purpose method for the solution of the Euler and Navier-Stokes equations suitable to resolve the characteristics compressible unsteady flow field past helicopter rotor blades in hover and forward flight. The core method should be implicit in space and time with a resolution that is 2nd order in time and at least 3rd-order in space (structured high-order methods will be highly-beneficial).

The time marching method could follow the dual-time step approach; however the use of novel techniques to reduce solution time would be highly beneficial (such as for instance ‘harmonic balance’ approach). The solver must be capable of addressing problems across the range of Mach numbers found on helicopter rotors.

Due to the geometrical complexity of the AGF system to be studied in this work, the capability to simulate active controls on helicopter rotor blade by using a full-unsteady Chimera approach will be highly-beneficial for the applicant. The capability to model helicopter rotors using a multi-block approach based on sliding meshes must be present. The capability for deforming and moving grids (to follow rigid and elastic motions of rotor blade) is considered to be mandatory in this case.

A detail description of software characteristics must be included in the Proposal, including all available turbulence modelling and simulation options. It is expected that the solver will have the capability to employ simple 1-equation turbulence models up to complex LES/DES schemes, and essential that it contain the standard popular 2-equation k-omega family models. It is expected that the limitations of the various turbulence models will be addressed in these studies.

Furthermore, it is considered essential that the software is capable of operating in parallel mode and should use the industry-standard Message Passing Interface (MPI) library.

Mesh generation for subsequent CFD simulations must be done using ANSYS ICEM®, and post processing of simulations using TECPLOT®.

A proven experience to simulate with the proposed CFD tool any kind of AGF systems for both airfoils and rotor blades (papers, conference presentations, etc...) will be a great advantage for the applicant.

Details of Wind Tunnel and Whirl Tower Tests

There are four AGF tests that are planned for GRC1.

The first test is a low speed 2D tunnel test of a wing section with full span AGF, on a full scale modified NACA0012 with thickened aft section to allow room for the AGF mechanism. The tunnel is unpressurised and capable of Mach numbers up to 0.2. This testing will comprise static aerofoil angles with static and dynamic AGF. Details of corrections to the wind tunnel data will be provided by the test facility.

The second test that will take place in a high speed wind tunnel. This is a 2D tunnel test of a wing section but utilising a modified existing helicopter blade aerofoil section. The testing of a near full scale section (0.3 to 0.4m chord) will be at Mach numbers between 0.2 to 0.6. For this test there shall be full dynamic testing with both fixed and oscillating aerofoil section, and fixed and deployable AGF. The wind tunnel section will include 50 steady pressure taps on the upper and lower surface and 30 high frequency pressure transducers. Additionally, there shall be extra tests possible with fixed Gurney Flap located at a range of chordwise positions. Details of corrections to the wind tunnel data will be provided by the test facility.

The final wind tunnel test is a 3D model rotor testin a large wind tunnel facility. This testing will comprise an isolated model rotor equipped with AGF devices. The rotor shall be tested at two rotational speeds and tunnel speeds of 45m/s to achieve high advance ratio conditions. PIV measurements are planned along with R&D tasks to infer surface pressures from PIV results.

The full scale whirl tower test is planned on a modified helicopter main rotor blade. This test will be used to prove AGF operation on an actual rotor blade and provide suitable aerodynamic data for CFD code validation.

Further Expectations

It is expected that the successful bidder will dedicate computing hardware to this work package throughout the contract period. Therefore, provisions for new hardware to be purchased specifically for computations of GRC1 test cases are acceptable but only within the JU rules for hardware acquisition and purchase.

Commercial Requirements

Detailed discussion of all relevant contractual requirements will take place following selection of the successful bidder. Management and protection of data transferred in support of this task is expected to be governed by a specific non-disclosure agreement (NDA), to be agreed as part of the detailed contract negotiations.

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

1. The applicant must have demonstrated experience in CFD validation in the helicopter rotor field.
2. Bidders are expected to demonstrate appropriate experience of CFD code development.
3. The winning bidder will be expected to provide full technical reports of any software upgrading, provide technical reports of all validation and blind test cases, and supply appropriate input and output files on suitable mass storage devices as required, together with the computational meshes used in the simulations.

3. Major deliverables and schedule

Deliverable	Title	Short Description (if applicable)	Due date (month)
M0	Contract Effective.		T_0
D1	Code Report.	Provide documentation describing the basic code and the associated code modifications (if any) required to accurately model the final defined AGF deployment method	T_0 + 9 months
D2	Report on Validation of CFD against 2D 1st series Wind Tunnel test data.	Report	T_0 + 14 months
D3	1st Report on Forward Flight Blind Test Cases.	Description of first blind test case results.	T_0 + 18 months
D4	Report on Validation of CFD tool against 2nd series of Wind Tunnel test data.	Report	T_0 + 26 months
D5	Report on Validation of CFD tool against Model Rotor Wind Tunnel test data in a large wind tunnel.	Report	T_0 + 28 months
D6	Report on Validation of CFD tool against Full Scale Whirl Tower test data.	.Report	T_0 + 36 months
D7	Final report on Forward Flight Blind Test Cases.	Description of complete blind test case results and release of all input/output files of the overall activities.	T_0 + 36 months

4. Topic value (€)

The total anticipated eligible cost of the proposal including manpower, travel costs, consumables, equipment, other direct costs, indirect costs, and subcontracting shall not exceed:

€ 320,000

[Three Hundred and Twenty Thousand euro]

(VAT not applicable)

5. 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)

- The expected maximum length of the technical proposal is 35 pages *with individual chapters for each of the key elements a) to e) defined in the scope of work*.

Topic Description

CfP topic number	Title		
JTI-CS-2013-01-GRC-02-016	**Assessment of optimized tiltrotor engine intake performance by wind tunnel tests**	**End date**	T0 +12 months
		Start date	T0: June 2013

1. Topic Description

1.1- Background:

The sub-project GRC2 "Drag reduction of airframe and non-lifting rotating systems" of the Green Rotorcraft ITD aims at improving the aerodynamic characteristics of tiltrotor engine installation. This implies a reduction of total pressure losses in the intake duct and a more uniform flow field at the engine Aerodynamic Interface Plane (AIP), together with an increased efficiency of the by-pass duct. Within the GRC2 sub-project, an optimization activity has been accomplished in order to achieve the targets above by means of Computational Fluid Dynamics (CFD) coupled with a Genetic Optimizer on the ERICA tiltrotor. Based on the baseline configuration, associates of the GRC Consortium performed shape optimization on different parts of the tiltrotor nacelle (intake, internal ducts, exhaust nozzles) for engine installation efficiency improvements purposes.
In this call-for-partner, the successful applicant will support the GRC Consortium in the benefit assessment process for the tiltrotor engine intake. The successful applicant of this call will experimentally assess by wind-tunnel tests an optimized intake system (including a rotating rotor hub) and will evaluate the benefits in comparison to the original configuration. The work comprises wind-tunnel model design and manufacturing, test preparation, test execution and results analysis. Moreover, innovative measurement activities, such as internal duct flow visualization, are envisaged.

1.2- Scope of work:

General objectives

The overall objective of the current Call for Proposal is to perform a benefits assessment of the ERICA tiltrotor engine intake system including rotor hub effects by performing:

a) design and manufacturing of a modular model suitable for testing both baseline and optimized solutions including engine and by-pass duct air flow. A mandatory feature of such model is that the internal flow must be represented as well as the capability to simulate the rotor hub effect

b) wind-tunnel tests of the intake system (with and without spinning rotor hub) with the objective of accurate pressure losses measurements, distortion evaluation and by-pass efficiency analysis to assess the global benefit of the shape optimization activities performed by the GRC Consortium. The partner is expected to provide detailed experimental benefit measurement between the "basic" configuration and "optimised" shape.

Both basic and optimized wind-tunnel models will be designed and manufactured by the applicant. The GRC Consortium will provide the CAD surface models (CATIA V5®) of the basic and optimized geometries together with the test specification, including the operating conditions to be tested.

The Call for Proposal activity is split into two main tasks as hereafter described:

- **Task 1**: Design and manufacturing of wind-tunnel model and instrumentation set-up
- **Task 2**: Wind-tunnel tests of the original and optimised configurations

Task 1:Design and Manufacturing of Wind Tunnel Models and Instrumentation set-up

Wind Tunnel Model

A dedicated wind tunnel model is required to the applicant. The model must be constituted by the following key elements:

- Internal structure supporting **interchangeable internal ducts**.
- **Suitable air piping system**, one for the engine air flow, one for the by-pass flow, must be included in the design in the less intrusive solution (a piping system embedded in the supporting wing is preferred, see Figure 2). The required fans to guarantee the desired mass flow are to be provided by the applicant.

- **Movable outer wing** (remote control not mandatory).
- **Tilting nacelle** (independent from the outer wing, remote control not mandatory).
- **Rotating rotor hub** (manual blade root pitch setting) with the possibility to be quickly dismounted (even partially) to allow the no-rotor (clean spinner geometry) test.

The general layout of the external wing and the nacelle is reported in Figure 1 (left), while the shape of the intake and by pass ducts is shown in cyan in the same picture (right).

Given a full scale wing span (distance between rotor axes) equal to 15 m, the wind tunnel model scale is imposed to be 1:2.5.

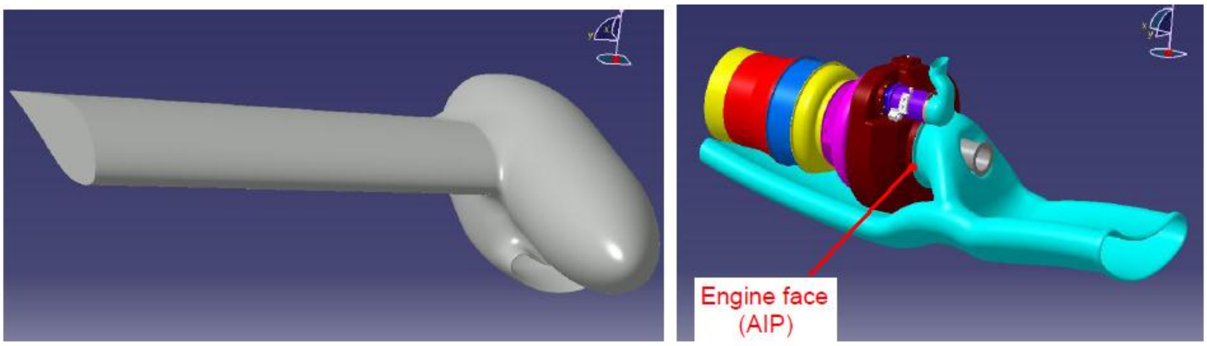


Figure 1: general outer wing and nacelle layout (left) and air intake and by pass duct shapes (right).

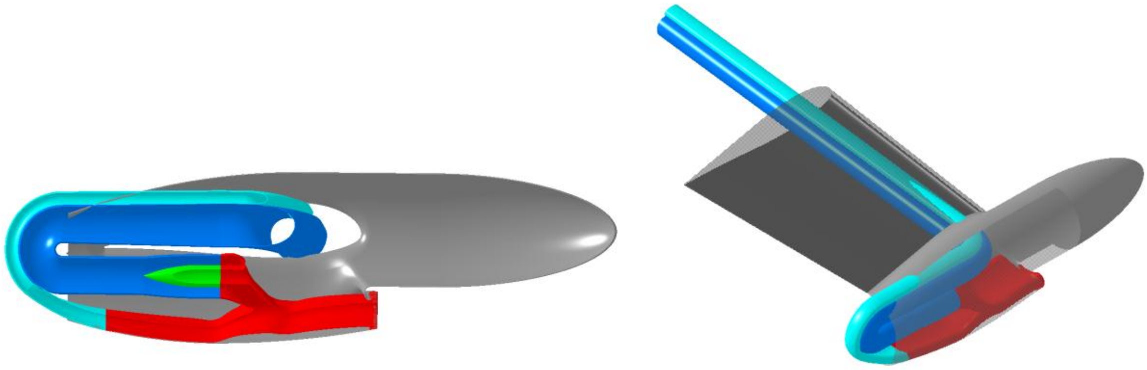


Figure 2: general internal duct layout.

Two intake and by pass duct shapes, reported in Figure 3, will be manufactured and tested:

- Basic (or Baseline)
- Optimized (or Design #2)

Both shapes are compatible with the same external surface (in particular in the intake lip region) and with the same air sucking interfaces (engine Aerodynamic Interface Plane, AIP) and by-pass exhaust)

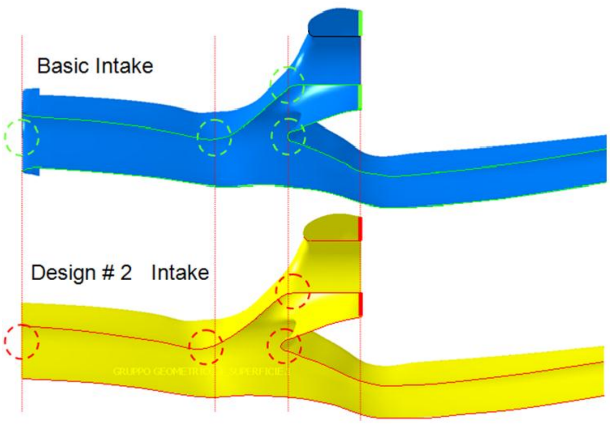


Figure 3: Intake and by-pass duct shapes to be tested.

Instrumentation

The applicant must be able to provide the instrumentation required for the measurement given below:

- **Static Pressure:** at least 100 static pressure taps placed both in the internal ducts and on the external nacelle surface, with suitable refinements in the S-shaped region and the inlet lip, to improve mapping in the regions characterized by the most relevant gradients
- **Total pressure:** probes (straight Pitot tubes) distributed on a 4-arms rake at the engine AIP in order to properly determine inlet distortion descriptors (DC60 indicator is required). An amount of 40 to 48 total pressure probes arranged in 8 rakes with 5 or 6 rings is the minimum required. Increased accuracy can be obtained if the radius of each ring is set such that all probes are at the centroids of equal areas. This means that probes radial spacing decrease from the inner most ring to the outermost ring. Rake should be able to be offset of 22.5 degrees in order to provide additional data by-means of multiple testes at the same condition. "Kiel" and "Cobra" probes are suggested to enhance the capability to define the different flow quantities (e.g. total pressure, flow direction, etc.).
- **Mass flow:** a Venturi tube (with transducers of pressure, temp. & humidity) provided the flow ratio measurement. A proper piping connecting the model outlets ("engine" and "by-pass" to a centrifugal fan, providing the required suction. both for engine and by-pass flows.
- **Visualizations:** any innovative flow visualization or measurement technique of internal (in ducts) flows is envisaged. It can be performed on a set of selected operating conditions and on a dedicated rig. An example of endoscopic vision set up for Particle Image Velocimetry (PIV), one of the possible proposal, is given in Figure 4.

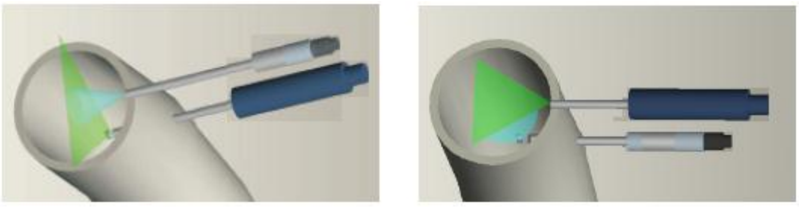


Figure 4: Sketch of the light sheet and vision endoscope set-up.

Inputs from GRC Consortium:

- CATIA V5® file of the original configuration (full scale external and duct surfaces).
- CATIA V5® file of the optimised configuration (full scale external and duct surfaces).
- Rotor data to support rotor hub effect representation. No blade geometry will be supplied.

Ouputs from Applicant:

- Manufacturing drawings.
- Wind tunnel modular model (baseline + optimized). The model, with the exclusion of fans and transducers, will be property of the GRC Consortium.

Task 2: Wind-tunnel tests of the original and optimised configurations

This task includes the activity of wind-tunnel tests preparation and execution for all the configurations, as well as the data analyses.

Test Conditions

The test conditions will cover the convenient speed, advancing ratio, wing and nacelle attitude angles (reported in Table 1) as well as the intake and by-pass flow rates. The following ranges will be initially assumed considering, for the scaled values, standard ISA conditions assuming a 1:2.5 model scale, a max wind tunnel speed of 50 m/s, a tunnel pressure of 101325 Pa (t=288.15°K) and a density of 1.225 Kg/m^3:

- 6 operating conditions: Cruise mode, Conversion modes 1, 2, 3, hover and hover OEI (30sec)
- attitude angles (to account for fuselage attitude and wing fixed setting angle):
  -5° to 10°

- outer wing and nacelle setting angles (relative to attitude angles): 0° to 80° and 0° to 85°
- AIP scaled mass flow ranges: 0.25 to 1.55 Kg/s (expected engine operative range)
- by-pass scaled mass flow ranges: 5 to 15% of AIP scaled mass flow ranges

Flight condition	True Air Speed [Kts]	True Air Speed [m/sec]	Pressure Altitude [m]	Static Pressure [Pa]	OAT [°C]	Density [Kg/m^3]	Speed of sound [m/sec]	Fuselage Incidence [deg]	Nacelle attitude [deg]	Outer wing setting angle [deg]	Rotor RPM
a) Forward flight cruise	300.00	154.3	7500.00	38251.4	-33.75	0.5566	310.175	-1.97	0.00	0.00	425.8
b) Conversion Mode 1	95.00	48.87	0.00	101325.0	15.00	1.2250	340.294	-4.72	85.00	12.00	553.0
b) Conversion Mode 2	120.00	61.73	0.00	101325.0	15.00	1.2250	340.294	1.59	60.00	0.00	553.0
b) Conversion Mode 3	160.00	82.31	0.00	101325.0	15.00	1.2250	340.294	0.59	30.00	0.00	553.0
e) Hover	0.00	0.00	0.00	101325.0	15.00	1.2250	340.294	3.22	85.00	80.00	553.0

Table 1: full scale operating conditions

A preliminary test matrix is shown in Table 2. A total number of 300 test points is estimated as:

- 6 Operating conditions (Cruise, Conversion1, 2, 3, Hover and Hover OEI)
- 36 points for each operating condition given by:
  - 2 geometries (Basic and Optimized)
  - 3 AIP mass flow rate values (sensitivity)
  - 3 By-pass mass flow rate values (sensitivity)
  - 2 Rotor Hub setting (On-Rotating and Off)
- 24 repeatability points (at nominal mass flow rate values)
- 60 set up, calibration and with innovative visualization techniques points

The wind-on time estimation is therefore estimated in 10 days, including changes in model configuration.

Condition	Intake configuration	Rotor Hub	Attitude angle [deg]	Outer wing setting angle [deg]	Nacelle setting angle [deg]	Wind Tunnel Air Speed [m/s]	Hub RPM [ ]	Nominal AIP Mass Flow Rate [kg/s]	AIP Mass Flow Rate sweep (3X, +/- 10%)	By-Pass Mass Flow Rate Ratio (relative AIP)	Repeatibility (nominal Mass Flow Rates only)	Number of test points
Cruise	Basic	On	-1.97	0.00	0.00	50	1065	0.491	On	5, 10, 15%	1	9
	Optimized	"	"	"	"	"	"	"	"	"	1	9
	Basic	Off	"	"	"	"	"	"	Off	"	1	9
	Optimized	"	"	"	"	"	"	"	"	"	1	9
Conversion 1	Basic	On	-4.72	12.00	85.00	50	1383	1.062	On	5, 10, 15%	1	9
	Optimized	"	"	"	"	"	"	"	"	"	1	9
	Basic	Off	"	"	"	"	"	"	Off	"	1	9
	Optimized	"	"	"	"	"	"	"	"	"	1	9
Conversion 2	Basic	On	1.59	0.00	60.00	50	1383	0.826	On	5, 10, 15%	1	9
	Optimized	"	"	"	"	"	"	"	"	"	1	9
	Basic	Off	"	"	"	"	"	"	Off	"	1	9
	Optimized	"	"	"	"	"	"	"	"	"	1	9
Conversion 3	Basic	On	0.59	0.00	30.00	50	1383	0.633	On	5, 10, 15%	1	9
	Optimized	"	"	"	"	"	"	"	"	"	1	9
	Basic	Off	"	"	"	"	"	"	Off	"	1	9
	Optimized	"	"	"	"	"	"	"	"	"	1	9
Hover	Basic	On	3.22	80.00	85.00	50	1383	1.139	On	5, 10, 15%	1	9
	Optimized	"	"	"	"	"	"	"	"	"	1	9
	Basic	Off	"	"	"	"	"	"	Off	"	1	9
	Optimized	"	"	"	"	"	"	"	"	"	1	9
Hover OEI	Basic	On	3.22	80.00	85.00	50	1383	1.550	On	5, 10, 15%	1	9
	Optimized	"	"	"	"	"	"	"	"	"	1	9
	Basic	Off	"	"	"	"	"	"	Off	"	1	9
	Optimized	"	"	"	"	"	"	"	"	"	1	9
										Sub-Total	24	216
										Grand-Total		240

Table2: preliminary test matrix (excluding set up and calibration points).

Inputs from GRC Consortium:

- Test specification document.

Ouputs from the Applicant:

- Wind-tunnel tests results including corrections for supporting system and all other noticeable effects (wall interferences, buoyancies, stream deviation, etc..).
- All raw and processed data.
- Report on data analysis on the basic configuration wind-tunnel tests.
- Report on data analysis on the optimised configuration wind-tunnel tests.

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

Wind-tunnel equipment and capabilities

The applicant must have a qualified and demonstrated skill in wind tunnel testing. It would even be preferred if he has already conducted wind tunnel test campaigns on engine intake configurations. Detailed requirements and specifications for the applicant capabilities are listed below:

- Wind speeds suitable to guarantee at least 50 m/s during tests.
- Pressure transducers suitable to acquire from the static and total pressure taps.
- Two fans suitable to guarantee the desired mass flow rates.
- Movable system (e.g. turning table) suitable to achieve the specified wing-nacelle incidence conditions

Legal

The partner will be asked to sign an Implementation Agreement

3. Major inputs, deliverables, milestones and schedule

The applicant is expected to present a detailed planning of the activity compliant with the deliverable and milestones table above, including cost and resources sharing per activity. Also a risk assessment is required.

4. Deliverables

Deliverable (D)/ Milestones(M)	Title	Short Description (if applicable)	Due date (month)
D1	Preliminary Design Review	Draft report describing the model layout to be manufactured.	$T_0 + 2$ (August 2013)
D2	Final Design Review	Report describing the model layout and allow the go on with manufacturing. Delivery of manufacturing drawings.	$T_0 + 3$ (September 2013)
D3	Wind Tunnel Test Plan	Report describing the proposed test plan, including expected test conditions, measurements, accuracy and corrections to be applied.	$T_0 + 8$ (February 2014)
M1	Wind Tunnel Model ready	Delivery of Wind Tunnel Model ready to be tested.	$T_0 + 9$ (March 2014)
D4	Wind tunnel test data analysis	Report describing the results including the measured test points and conditions, acquired data, accuracy, corrections applied and comparison between configurations.	$T_0 + 12$ (June 2014)

5. Topic value (€)

The total anticipated eligible cost of the proposal including manpower, travel costs, consumables, equipment, other direct costs, indirect costs, and subcontracting shall not exceed:

EUR 450,000 (VAT not applicable)

(F**our Hundred and Fifty Thousand euros**)

6. 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 or manufacturing, 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)

The expected maximum length of the technical proposal is 50 pages.

Topic Description

CfP topic number	Title		
JTI-CS-2013-01-GRC-02-017	Contribution to the aerodynamic design of a helicopter air intake through wind tunnel testing	**End date**	T0 + 24 months
		Start date	T0

1. Topic Description

1. Background:

The sub-project GRC2 „Drag reduction of airframe and non-lifting rotating systems“ of the Green Rotorcraft ITD aims among other things at improving the aerodynamic characteristics of helicopter engine installations. For this purpose, the reduction of total pressure losses in the intake system as well as the minimization of flow distortion at the Aerodynamic Interface Plane (AIP) of the engine, located in front of the compressor, is mandatory.

Within work package 2.3 of the Green Rotorcraft ITD, a numerical optimization by means of Computational Fluid Dynamics (CFD) is performed by the GRC Consortium to achieve the above stated targets.

The successful applicant (Partner) shall experimentally evaluate the engine air intake concepts provided by the GRC consortium by means of wind tunnel tests. The applicant is responsible for the detailed design and manufacturing of the wind tunnel model, the test preparation and execution as well as the analysis, preparation and reporting of the measurements. Moreover the Partner shall propose local, retrofit modifications to the baseline intake, with the objective of improving its aerodynamic characteristics in agreement with the topic leader. The proposed modifications shall be assessed through wind tunnel testing by the Partner.

2. Scope of work:

The purpose of this topic is the assessment, through wind tunnel testing, of the benefits expected from a number of engine air intake shape modifications that will be selected by the GRC Consortium.

In order to assess the benefits of the aerodynamic design modifications, different engine air intake configurations are to be measured in wind tunnel. Therefore, the following tasks are required:

Task 1: **Design, manufacturing** and **instrumentation** of the engine air intake wind tunnel models.

Task 2: **Execution of the wind tunnel campaign with different engine air intake configurations and post-processing of measurement data**.

Task 1 – Design, Manufacturing and Instrumentation

Input:

The **GRC Consortium** will deliver the specifications for the model manufacturing and instrumentation. This will consist in CATIA V5 CAD files of the geometries to be tested in wind tunnel accompanied by a specification document describing the necessary instrumentation **(In-1)**.

Model:

The **Partner** shall design, manufacture and instrument the wind tunnel model following the specifications provided by the GRC Consortium. The model shall consist of the following main components:

- Local part of the helicopter engine cowling and cabin around the engine air intake so that a realistic oncoming flow is ensured;
- Engine air intake with an internal supporting structure that allows installing different intake concepts;
- Plenum chamber with an internal supporting structure that allows installing different intake concepts and local modifications inside the plenum;
- Engine intake duct with engine intake guide vanes;
- Foreign object damage grids in front of the engine air intake and the engine intake duct that can be mounted or dismounted for the wind tunnel test;

The wind tunnel setup shall include the following installations:

- System to simulate the suction effect of the engine to achieve the specified air mass flow rate.
- Supporting structure for the whole model, that allows to set different wind tunnel model yaw angles.

A general layout of the helicopter engine cowling and an exemplary engine air intake is depicted in figure 1-1 left. Figure 1-1 right shows the engine air intake, the plenum chamber and exemplarily a possible engine intake duct down to the engine compressor. Figure 1-1 right also depicts the general location of the aerodynamic interface plane (AIP) in front of the compressor where the total pressure and flow velocity shall be measured.

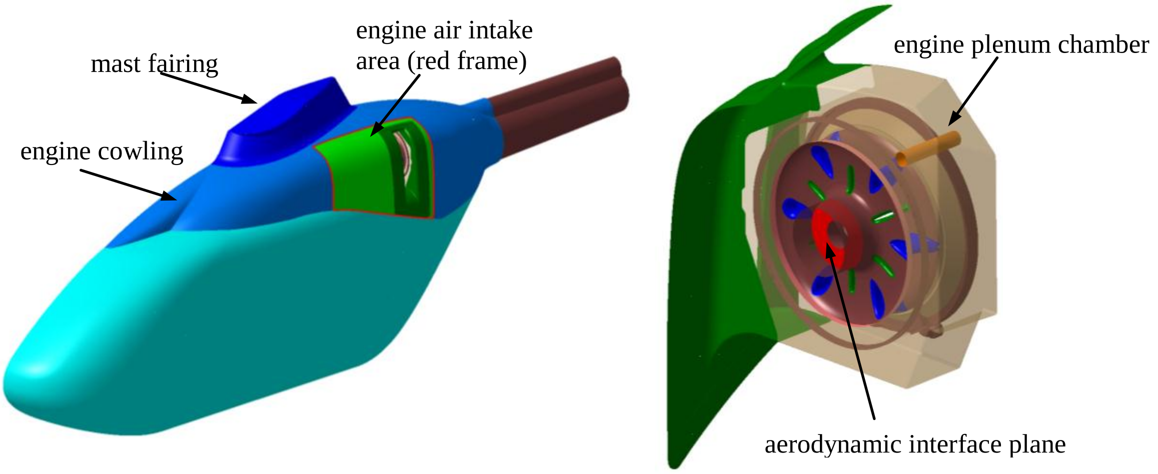


Figure 1-1: general layout: engine cowling, mast fairing, cabin, engine air intake, plenum chamber, engine

The wind tunnel model shall be at full scale (1:1). Globally the model length is not to exceed 4.5 [m]. To reduce the frontal area of the model and the wind tunnel blockage respectively the engine and engine plenum might be installed under floor (see figure 1-2). The frontal area will not exceed 0.4 [m^2].

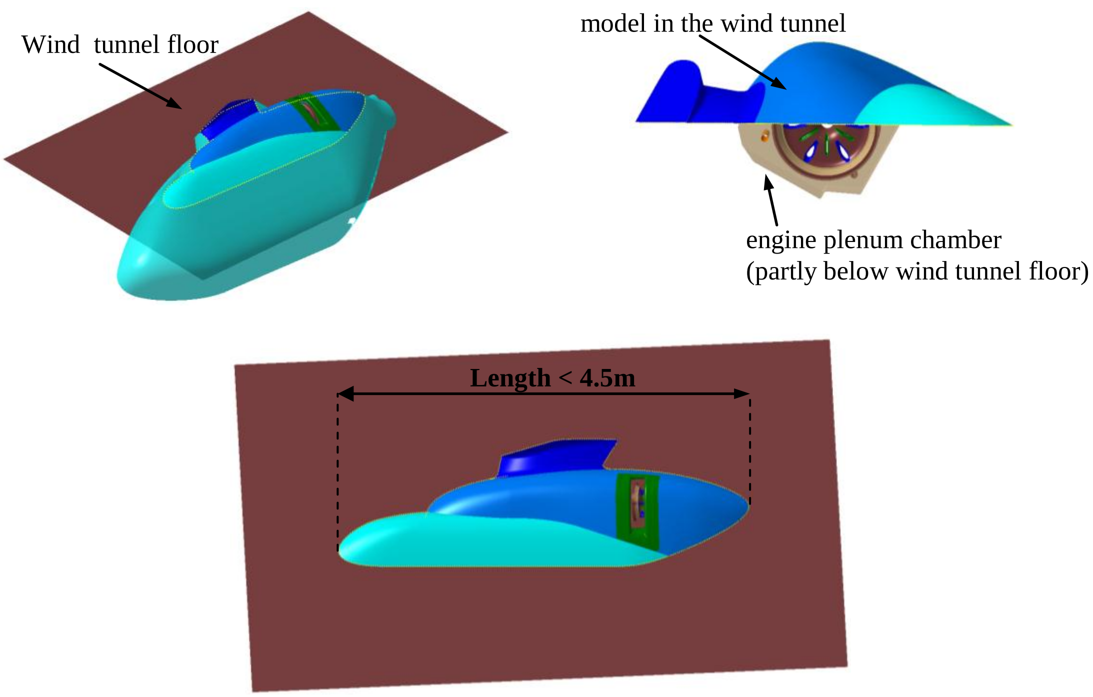


Figure 1-2: Exemplary layout of a wind tunnel setup

The fuselage and engine cowling will be simplified. Some geometric details will be retained in the area of the engine air intake, engine intake duct and plenum chamber. Especially the grids installed in front of the air intake and in front of the engine intake duct to protect the engine against foreign object damage must be representative, i.e. frame dimensions and grid characteristics (wire thickness, shape and spacing) to be specified by the GRC consortium.

Three different engine air intake concepts shall be manufactured and tested by the Partner. All of them are compatible with the same helicopter engine cowling. In addition the Partner shall manufacture between two and four different aerodynamic solutions such as guide vanes, spoilers or inlet scoops installed in the engine air intake (green area in figure 1-1 limited by the red frame) in combination with maximum two of the three different air intakes. Furthermore different retrofit solutions for the plenum chamber – such as rounded edges and or flow deviators – as well as a minimum of two different foreign object damage grids installed in front of the engine air intake shall be manufactured and tested in combination with maximum two intake variants.

Instrumentation:

The necessary instrumentation shall be arranged by the **Partner** to perform the following measurements:

- **Static pressure** measurements through pressure taps at not less than 180 locations located on the engine cowling, engine intake area, plenum chamber and engine intake duct **defined by the GRC Consortium in collaboration with the Partner**;
- **Unsteady pressure** measurements through pressure transducers (*e.g.* Kulite®) at not less than 12 locations on the engine cowling, intake area, plenum chamber and engine duct **defined by the GRC Consortium in collaboration with the Partner**;
- **Total pressure** measurements inside the engine duct (at the AIP) at not less than 32 locations distributed on not less than 8 azimuth and 4 radial positions to determine total pressure losses relative to free stream conditions as well as flow distortion (for example: DC60 coefficient) in the engine duct; locations will be **provided by the GRC Consortium**
- **3-component flow velocity** measurements in the engine duct (at the AIP); location will be **provided by the GRC Consortium**
- **3-component flow velocity** and turbulence intensity measurements above the engine cowling to assess the oncoming flow and in the engine intake area; location will be **defined by the GRC Consortium in collaboration with the Partner**

The instrumentation list above holds for one intake concept. Other versions of the engine intake, engine duct and plenum chamber shall be equally instrumented.

Output:

Instrumented wind tunnel models of the different engine air intake configurations **(D-1a)**.

Report on design, manufacturing and instrumentation **(D-1b)**.

Task 2 – Execution of wind tunnel campaign of baseline and optimized configurations

This task includes the preparation and execution of the wind tunnel tests of all engine air intake configurations as well as the data analysis and reporting.

Input:

The **GRC Consortium** will deliver the specifications for the wind tunnel entry. A detailed measurement matrix will be provided (**In-2**).

Wind Tunnel Measurements:

During the wind tunnel campaign each intake concept and design modification shall be tested with a set of different wind speeds, engine air mass flows and engine cowling angle of yaw settings. To simulate helicopter environmental conditions ranging from hover to cruise flight, the wind speed shall be increased between 0m/s up to at least 55m/s with not less than 4 intermediate wind speeds. The engine air mass flow rate shall also be modified by increasing and decreasing it starting from a nominal value representative for the wind speed or flight condition respectively. The range of engine air mass flow rate corresponds to the range between hover and cruise flight and shall therefore be altered between 1.0 kg/s and 2.0 kg/s. To simulate different helicopter attitudes, the wind tunnel model shall be yawed by at least +/- 5deg from the initial position.

Summarizing the wind tunnel test setup:

- wind speed settings: at least 6 settings ranging from 0m/s to at least 55m/s
- engine air mass flow range (at AIP): 4 settings between 1.0 kg/s and 2.0 kg/s
- engine cowling angle of yaw: -5deg up to +5deg (a maximum of three settings)

During all wind tunnel tests the Partner shall conduct all static and total pressure measurements, all unsteady pressure measurements as well as flow velocity measurements with the instrumentation as specified above so that for each configuration the aerodynamic characteristics of the engine air intake as well as of the approaching flow can be evaluated.

The sequence of the wind tunnel test activities shall be arranged in at least two different phases. After each measurement phase the Partner shall prepare the measured data so that the GRC Consortium and the Partner can select the engine air intake concept and aerodynamic installations for the next test activities. During the first wind tunnel phase the three different engine air intake concepts shall be tested. After results assessment, the second wind tunnel phase shall investigate the aerodynamic installations in terms of guide vanes, spoilers, flow separators, grid and plenum modifications as well as the effect of the foreign object damage grid by removing the grid for a specified number of test points.

Overall not more than 600 test points obtained by varying the geometry configuration, wind tunnel speed, engine air mass flow and engine cowling yaw angle will be measured by the Partner.

Output:

The measurement data coming from the wind tunnel campaign shall be exhaustively documented in a dedicated report. This deliverable shall comprise the experimental data base, all applied corrections and a written report on the experiment **(D-3)**.

Furthermore the raw data and the processed data shall be delivered at the end of each wind tunnel phase **(D-2.i)**.

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

The applicant must have a qualified and demonstrated skill in wind tunnel testing. With the model mounted in the test section, the minimum wind speed shall reach at least 55m/s, the turbulence intensity should be less than 0.4%. The test section should have a cross-section area of at least 4.2m^2. The necessary instrumentation as well as the air system to guarantee the desired engine mass flow rates shall be provided by the Partner.

The mandatory skills are:

- Mock-up design, manufacturing and instrumentation.
- Aerodynamic measurements.
- Wind tunnel test management.

3. Major Deliverables and Schedule

Input or Deliverable	Title	Short Description (if applicable)	Due date (month)
In-1	*Specifications for wind tunnel model manufacturing and instrumentation*	• *CATIA V5 file of the wind tunnel model* • *Specification document describing the necessary instrumentation*	*T0+1*
D-1a/b	Instrumented wind tunnel model and reporting	• Model composed of fuselage, engine cowling, engine duct and complete air intake (all variants) • All necessary instrumentation • Documentation about design, manufacturing and instrumentation of the wind tunnel model	T0+9
In-2	*Specifications for the first wind tunnel entry*	• *The measurement matrix will be specified in details*	*T0+7*

D-2.i	Wind tunnel measurement data of all configurations	• All measurement data (raw and post-processed) of the wind tunnel campaign (Task 2)	at the end of phase i
D-3	Reporting of all wind tunnel measurement results	• Documentation of all results of the wind tunnel campaign (Task 2)	T0+24

The Partner is expected to present a detailed planning of the activity compliant with the deliverable and milestone planning stated above, including cost and resource planning per activity as well as a risk assessment.

4. Topic value (€)

The total anticipated eligible cost of the proposal including manpower, travel costs, consumables, equipment, other direct costs, indirect costs, and subcontracting shall not exceed:

€ 450,000 (VAT not applicable)

(Four Hundred and Fifty Thousand euro)

5. 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 may concern only 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.
- the call is subject to budget availability.

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

The expected maximum length of the technical proposal is 40 pages.

Topic Description

CfP topic number	Title		
JTI-CS-2013-01-GRC-05-008	Innovative measurement and monitoring system for accurate on-board acoustic predictions during rotorcraft approaches and departures	**End date**	T0 +24 months
		Start date	T0

1. Topic Description

1.1 – Background:

In the frame of the CLEANSKY Joint Undertaking, the Green Rotorcraft Integrated Technology Demonstrator is committed to develop and test new flight procedures for both helicopters and tiltrotors, aiming at significantly reduce environmental impact in terms of noise and gas emissions.

Helicopter generated noise significantly depends on the instantaneous value of three parameters, the knowledge of which allows realistic estimates of rotorcraft acoustic impact: the angle of attack (AOA) of rotor tip-path-plane (TPP), rotor thrust and vehicle airspeed. Numerical studies (see for example Refs. [1], [2]) show significant results in terms of noise abatement procedures considering steady-state mappings of acoustic noise levels based on estimates of these three quantities, which are rather straightforward in a simulation environment for both main and tail rotors.

For run-time on-board applications, the usual vehicle sensor measurements (airspeed, attitude, rate of climb, etc.) provide sufficient information to estimate rotor AOA and thrust in steady conditions only. Perturbed and maneuvering flight conditions (for example acceleration, deceleration, entry and exit from steady turns) are quite typical of approach and departure procedures, expecially in case of wind or turbulence. Therefore in-flight estimate of helicopter noise calls for innovative solutions to measure rotor states, in particular the so called cyclic flapping angles (longitudinal and lateral), to estimate the AOA of rotor TPP and rotor thrust in flight.

For departures and approaches, numerical and practical experiences indicate a strong dependence of helicopter noise on main rotor AOA (because of its changes with climb and descent velocity, while tail rotor AOA has limited effects), a mild but relevant dependence on the thrust of main rotor (which is subject to limited variations in the considered conditions), and a significant variation in noise generated by the tail rotor between take-off and landing conditions, due to large changes in pilot pedal controls and associated thrust loading variations.

The proposed activity will focus on the design, development and test of an integrated system intended to return run-time information on vehicle noise in non-steady conditions. This system will include

(i) an innovative on-board apparatus devoted to the measurement of main rotor cyclic flap angles: contactless systems shall be considered in particular, as they are less dependent on rotor geometry and less subject to static and vibratory loads, allowing easier installation and higher reliability;

(ii) the necessary signal conditioning system, able to aquire, filter and compensate sensor signals producing digital outputs to feed rotorcraft on-board system (e.g. AFCS);

(iii) an estimation algorithm for main rotor AOA, main rotor thrust and tail rotor thrust, based on the knowledge of the usual vehicle sensor measurements augmented by measured rotor flap angle signals;

(iv) acoustic prediction algorithm, compatible with GRC5 developed technologies, fed by the above estimates and producing the noise signal to be displayed by the Pilot Acoustic Indicator;

(v) a graphical display (Pilot Acoustic Indicator) of the noise signal to the pilot, to enhance his cues and situational awareness.

Final demonstrations will be based on piloted simulations and ground testing on a helicopter prototype. No formal certification of the system will be required. Nevertheless, the developed systems are intended for application on production helicopters (certified under CS 27/29), so design and development must consider relevant requirements, in particular regarding safety, environmental conditions, human-machine interface and software implementation.

1.2 – Scope of work:

The activity will be organized in three main tasks: (1) acoustic prediction, (2) innovative measurement system, and (3) innovative in-flight monitoring.

The contribution is expected to last apprimately 2 years (not mandatory), starting from T0.

1.2.1 – Task 1 – Acoustic Prediction:

Aim of this task is to show the importance of in-flight measurement of rotor state to accurately estimate the main rotor radiated noise in run-time. A secondary outcome will be the analysis of the possible limitations of the approach based on the quasi-steady acoustic maps (i.e. the footprint noise prediction of unsteady maneuvers as the "sum" of quasi-steady flight path segments) with respect to a more advanced approach that takes into account the embedded unsteadiness of the flight conditions. Finally, it will be possible to apply the acoustic prediction to assess of the robustness of unsteady flight path to perturbations or deviations from the intended one.

The selected Applicant will provide the expertise and tools to predict the helicopter external noise due to main and tail rotors in maneuvering flight. The activity shall be structured in four main phases:

Phase I – Based on the technical details agreed with the helicopter manufacturer at the kick-off, the Applicant will adapt and upgrade, if necessary, its in-house tools and capabilities to receive main and tail rotor aerodynamic loads as inputs from GRC5 consortium. In particular, the Applicant will receive from GRC5 Consortium the aerodynamic blade loads (for both main and tail rotor) in the so-called chordwise compact model (in other words only the spanwise airloads on the blades will be supplied) for a conventional helicopter configuration. The Applicant will receive the necessary input data for the unsteady acoustic analysis and for the steady equivalent acoustic analysis, i.e. to compute typical vehicle acoustic hemispheres in trimmed flight. The flight conditions will include (but will not be limited to) the flight envelope to be experimentally covered with a real helicopter.

Phase II – The Applicant will perform the acoustic analysis by predicting the radiated noise on ground (including typical atmospheric/terrain effects) in some selected flight conditions, conditions to be accomplished in a dedicated flight test campaign of GRC5 Consortium. In particular, a comparison is requested between these experimental acoustic measurements and the following numerical predictions:

A. full unsteady (acoustics and flight dynamics) noise footprint, given as inputs the full unsteady estimate/experimental measurement of flight parameters, (main and tail) rotor states and thrust, and rotor airloads, representing the best obtainable acoustic prediction;

B. quasi-steady noise footprint, based on steady acoustic hemispheres (as described in Phase I) and full unsteady estimate/experimental measurement of flight parameters, (main and tail) rotor states and thrust: this test represents the typical "desktop" acoustic numerical prediction in GRC5 and potentially the acoustic prediction available in flight in case a rotor AOA measurement system and thrust estimator is present;

C. "in-flight-estimated" noise footprint, based on the acoustics of point B but with flight parameter estimates numerically obtained by the Applicant from the experimental measurements as it would be possible on board a rotorcraft not equipped with rotor AOA measurement system.

This activity will constitute the validation phase of the Applicant methodology and the demonstration of the expected benefit of rotor AOA measurement system in terms of on-board acoustic prediction capability. Deliverable D1.1 is required.

Phase III – Once the methodology has been validated as per Phase II, the Applicant will perform the necessary acoustic analyses (on-ground acoustic propagation not mandatory in this case) to highlight strengths and drawbacks of the more challenging full unsteady flight path simulation (approach A above) with respect to the classical quasi-steady equivalent flight simulation (approach B) and the possible in-flight estimate (approach C). To do this, the Applicant will take advantage from the remaining part of the data base as received in Phase I but not exploited in Phase II for code validation. Deliverable D1.2 is required.

Phase IV – Finally, the task will culminate with the investigation of the effects of deviation from reference (baseline/conventional and/or optimized/steep profiles) flight path due to external perturbations or control input oscillation typical or real-life execution of low-noise procedures. Suitable data will be provided to the Application in the same format as in phases before. Deliverable D1.2 is required. Optionally, the results of Phase III and Phase IV can be splitted into two separate deliverables.

The number of considered baseline maneuvers/trajectories will be at least 6 (typically 3 departures and 3 approaches), but they will be negotiated and defined at project kick-off together with steady trim conditions to be analyzed.

1.2.2 – Task 2 – Innovative Measurement System:

Aim of this task is the development of the innovative rotor measurement system, with strong synergy between Applicant and helicopter Manufacturer.

In case the sensor system is installed on rotating components (e.g. hub or blades), the transducers will typically provide analog signals feeding a rotor slip ring (or similar apparatus, responsability of the Manufacturer), which will in turn transmit the information to the conditioning system installed on non-rotating helicopter components. Although not flight-critical and ultimately demonstrated on a prototype, the design of the innovative measurement system is expected to comply with relevant requirements for airworthiness, with the perspective of application on production helicopters. Final systems are expected to estimate static (i.e. low frequency) AOA and thrust with a 1-5% accuracy in realistic flight conditions (such as in presence of oscillatory loads, vibration, external turbulence). In assessing the impact of the selected technologies throughout Phases I-II-III, the Applicant is invited to investigate innovative concepts and algorithms in the fields of control laws, in-flight helicopter monitoring or identification, to show potential benefits in pilot/vehicle capability to execute precise low-noise procedures with minimal workload.

The task will be organized in four distinct phases.

Phase I – Evaluation of competitive technologies. Starting from Manufacturer’s needs and constraints (Deliverable D2.1), the Applicant will perform a comprehensive review and trade-off study of technologies available on the market to provide light-weight, cheap, safe, reliable and airworthy measurement systems of rotor AOA and thrust (to be reported in Deliverable D2.2). The specific requirement is to investigate innovative contactless (for example optical or laser) solutions. The Applicant will determine, in agreement with the helicopter Manufacturer, the high-level requirements of the innovative system to be developed (Deliverable D2.3). This phase will allow the selection of two promising approaches to develop in the next phase, the statement of the expected benefits and definition of system targets (weight, power consumption, performance, accuracy, etc.).

Phase II – Preliminary Design. Two selected technologies will be preliminarly evaluated through numerical and experimental activities, to assess their applicability, functional characteristics, accuracy, tuning required, before moving to detailed design and integration in the final demonstrator. The two concepts will be formally assessed with the Manufacturer through a Preliminary Design Review (PDR) and reported in a design document (Deliverable D2.4). At the PDR, Applicant and Manufacturer will select the preferred technology of the two for detailed design and final demonstration, and will update the expected benefits and system targets with respect to Phase I.

Phase III – Detailed Design. The final design selected in Phase II will be continued, covering implementation to full-scale, test-bed installation, calibration and testing in representative operating conditions, and final integration in the target vehicle configuration. The developed system will be formally assessed with the Manufacturer through a Critical Design Review (CDR) and reported in a design document (Deliverable D2.5). At the CDR, system applicability, performance and characteristics will be reviewed, with possible design changes and iterations until achievement of the targets agreed between Applicant and Manufacturer in Phase I and updated in Phase II.

Phase IV – Final demonstration. After formal acceptance at the CDR, the developed system will be tested on a prototype helicopter (interface with helicopter experimental acquisition system expected) to execute on-ground verification, validation and demonstration tests. Necessary support by the Manufacturer will be negotiated at project kick-off and provided. Deliverable D2.6 is required.

1.2.3 – Task 3 – Innovative In-Flight Monitoring System:

Aim of this task is the development of the innovative in-flight monitoring system.

The developed system will include the necessary algorithm to elaborate vehicle status data (such as airspeed, attitude, rate of climb, etc.) and main rotor flapping signals from the innovative measurement system (Task 2, section 1.2.2), providing a suitable noise signal to be displayed by a dedicated graphical device, the Pilot Acoustic Indicator, to convey relevant information on the produced external noise to the pilot at run-time.

Phase I – The selected Applicant will develop an estimation algorithm for main rotor AOA, main rotor thrust and tail rotor thrust, based on the knowledge of the usual vehicle sensor measurements augmented by measured rotor flap angle signals, to feed the noise prediction algorithm developed in

Task 1 (section 1.2.1). Furthermore, he will study the best indicator to synthesize external noise information enhancing awareness without impacting pilot workload.

Phase II – The selected Applicant will agree with the helicopter Manufacturer and test pilots the HMI requirements (Deliverable D3.1) and all the hardware and software interfaces for the final demonstration (piloted simulation at Manufacturer's premises). The Applicant will then perform the design, implementation and integration of the final software package on a stand-alone hardware prototype (like a tablet pc or similar) and assess it through a design review with the Manufacturer (Deliverable D3.2).

Phase III – Applicant and Manufacturer will test and demonstrate the indicator using a real-time vehicle simulator provided by the helicopter Manufacturer and operated by Manufacturer's test pilots. Using the numerical tools and developments in Task 2, the Applicant shall support the Manufacturer in updating sensor numerical models and software tools to correctly represent the in-flight operation of the innovative monitoring system combined with the innovative measurement system. Deliverable D3.3 is required.

1.3 – References:

[1] H.-N. Chen, K.S. Brentner, S. Ananthan, J. G. Leishman, "A Computational Study of Helicopter RotorWakes and Noise Generated During Transient Maneuvers", American Helicopter Society 61st Annual Forum, Grapevine, TX, June 1 – 3, 2005.

[2] A.L. Duc, P. Spiegel, F. Guntzer, M. Lummer, H. Buchholz, J. Götz, "Simulation of Complete Helicopter Noise in Maneuver Flight using Aeroacoustic Flight Test Database", American Helicopter Society 64th Annual Forum, Montréal, Canada, April 26th – May 1st , 2008.

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

To achieve the expected contributions, skills and capabilities are required in the following domains:

(1) unsteady rotor noise prediction;

(2) design, development and test of measurement systems, in particular associated to noise and vibration reduction aerospace applications;

(3) conceivement of simple airborne display systems.

To support these capabilities, the following tools, facilities and process standards are considered mandatory:

(1) advanced unsteady acoustic numerical tool;

(2) experimental lab to perform structural and fatigue tests on the developed measurement system;

(3) proven experience in designing systems compliant with FAR/CS 27/29.

Proven capabilities in the following areas will be considered desireable:

(1) capability to comply with MIL-810 / RTCA DO-160 and RTCA DO-254;

(2) previous participations in national or European research projects or working groups.

3. Major inputs, deliverables and schedule

The applicant will receive suitable inputs by the GRC5 consortium and specifically by the involved vehicle manufacturer, as follows:

- experimental flight and acoustic data, as provided by GRC5 flight test activities, all the necessary support to analyze them, and associated numerical estimates of flight parameters, airloads, etc. as necessary;

- vehicle system detailed design data as required by the activity (to be agreed);

- possible previous background on rotor measurement systems, HMI and applications.

Deliverable	Title	Description (if applicable)	Min due date	Max due date
D1.1	Unsteady noise predictions and correlation with flight test data	Report of the preliminary activities on unsteady noise prediction performed, and comparison against GRC5 experimental noise footprint data.	T_0+12 M	T_0+12 M
D1.2	Noise impact of simulation models (steady vs. unsteady)	Application of the noise prediction tools to analyse the main differences between the unsteady flight path simulation and the	T_0+21 M	T_0+21 M

	and deviation from theoretical unsteady flight path due to perturbation.	equivalent quasi-steady motion simulation. The robustness of the theoretical unsteady flight path to perturbations will be also included.		
D2.1	Requests, constraints and limitations for helicopter rotor state measurement systems	Initial statement agreed between Applicant and Manufacturer aimed at capturing needs and constraints into high-level requirements for system concept development, design, installation and testing. This document will feed the initial evaluation of competitive technologies.	T_0+0.5 M	T_0+1 M
D2.2	Evaluation of competitive technologies for an innovative rotor state measurement system	Review of current and future applicable technologies, focused on in-flight, contactless rotor blade flapping measurement.	T_0+2 M	T_0+4 M
D2.3	Innovative rotor state measurement system requirement specification	Detail of requirement specification for the two conceptual systems selected in the competitive technology evaluation, to be developed in the preliminary design phase	T_0+3 M	T_0+5 M
D2.4	Measurement system Preliminary Design Document	Result of the Preliminary Design Review, reporting the design and development activity performed	T_0+9 M	T_0+12 M
D2.5	Measurement system Detailed Design Document	Result of the Critical Design Review, detailing the design of the final flapping measurement system developed and reporting the experimental activity performed	T_0+14 M	T_0+18 M
D2.6	Final demonstrations	Report on the final demonstration of rotor state measurement system	T_0+24 M	T_0+24 M
D3.1	Pilot Acoustic Indicator requirements	Document on possible alternative display solutions and final requirements agreed with GRC5 helicopter Manufacturer	T_0+2 M	T_0+4 M
D3.2	Pilot Acoustic Indicator Design Document	Report on the design, implementation and preliminary tests of the pilot acoustic noise indicator	T_0+9 M	T_0+12 M
D3.3	Pilot Acoustic Indicator final demonstration	Report on the demonstrations of the developed pilot indicator performed by piloted simulations	T_0+15 M	T_0+18 M

4. Topic value (€)

The total anticipated eligible cost of the proposal including manpower, travel costs, consumables, equipment, other direct costs, indirect costs, and subcontracting shall not exceed:

EUR 1,500,000 (VAT not applicable)

[One Million and Five Hundred Thousand euro]

5. 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)

- The expected maximum length of the technical proposal is 80 pages.

Clean Sky – Sustainable and Green Engines

Identification	ITD - AREA - TOPIC	topics	VALUE (€)	MAX FUND (€)
JTI-CS-SAGE	**Clean Sky - Sustainable and Green Engines**	**17**	**22,100,000**	**16,575,000**
JTI-CS-SAGE-01	*Area-01 - Open Rotor Demo 1*			
JTI-CS-SAGE-02	*Area-02 - Open Rotor Demo 2*		**7,100,000**	
JTI-CS-2013-01-SAGE-02-030	Open Rotor propellers Ice Protection System.		2,000,000	
JTI-CS-2013-01-SAGE-02-031	SAGE2 Engine In-flight Balancing System		4,000,000	
JTI-CS-2013-01-SAGE-02-032	Study and durability of electrically insulative material in aircraft engine chemical environment		500,000	
JTI-CS-2013-01-SAGE-02-033	High speed metallic material removal under acceptable surface integrity for rotating frame		600,000	
JTI-CS-SAGE-03	*Area-03 - Large 3-shaft turbofan*		**4,450,000**	
JTI-CS-2013-01-SAGE-03-021	TCC Manifold Architecture Parametric Model development		600,000	
JTI-CS-2013-01-SAGE-03-022	Shared lubrication starting system		500,000	
JTI-CS-2013-01-SAGE-03-023	Microstructure Based Material Mechanical Models for Superalloys		850,000	
JTI-CS-2013-01-SAGE-03-024	Electric Pump for Safety Critical Aero engine applications		1,750,000	
JTI-CS-2013-01-SAGE-03-025	Variable fluid metering unit for Aero engine applications		750,000	
JTI-CS-SAGE-04	*Area-04 - Geared Turbofan*		**7,400,000**	
JTI-CS-2013-01-SAGE-04-020	Development of a robust forging process for a new advanced aero-engine rotor material		1,000,000	
JTI-CS-2013-01-SAGE-04-021	Development of an advanced forging process for optimised turbine casing material		600,000	
JTI-CS-2013-01-SAGE-04-022	Development of an advanced long life Ceramic Matrix Composite (CMC) turbine component		1,000,000	
JTI-CS-2013-01-SAGE-04-023	Development of a high flexible, low cost single crystal casting production process		1,500,000	
JTI-CS-2013-01-SAGE-04-024	Development of a Power Gearbox Rig		3,300,000	
JTI-CS-SAGE-05	*Area-05 - Turboshaft*			
JTI-CS-SAGE-06	*Area-06 - Lean Burner*		**3,150,000**	
JTI-CS-2013-01-SAGE-06-004	Design methods for low emissions		1,300,000	
JTI-CS-2013-01-SAGE-06-005	Design methods for durability and operability of low emissions combustor		850,000	
JTI-CS-2013-01-SAGE-06-006	Advanced materials for lean burn combustion system components using Laser- Additive Layer Manufacturing (L-ALM)		1,000,000	

Topic Description

CfP topic number	Title		
JTI-CS-2013-01-SAGE-02-030	**Open Rotor propellers Ice Protection System.**	**Start date**	T0
		End date	T0 + *30* months

1. Topic Description

The SAGE2 Demonstration Project aims at designing, manufacturing & testing a Counter-Rotating Open-Rotor Demonstrator. It involves most of the best European Engine & Engine Modules & Sub-systems Manufacturers.

RTD activities are foreseen on developing a new IPS (Ice Protection Systems) for the propeller blades. The objective of the work proposed in this CfP, is to design/implement this technology and demonstrate it to TRL4 (Technology Readiness Level).

Ice protection systems will be integrated onto engine rotating blades made of composite material.

It would be advantageous for the partner to consider how the system could be designed, manufactured, integrated and tested.

Task 1 :State of the art : materials and technologies

Partner is requested to investigate general state of the art of IPS, even beyond customer specifications (eg not only aeronautical application).

Partner is expected to present a large range of available and/or future technologies that are involved in ice protection.

Partner is requested to present a state of the art of current research work related to ice protection as well as patents related to this technology.

Task 2 : Screening of materials and technologies

Using the results of the previous task, Partner is requested to pre-select solutions applicable to Open Rotor blade requirements. Systems can be divided in two categories:

Active technologies:

Partner is requested to investigate active IPS technologies against customer specifications.

The following technologies shall be investigated (but not limited to):

- Heating surface external (film) or embedded in the blade material.
- Laser heating.
- Hot air heating.
- Micro-wave heating.

A first evaluation of power supply, electrical connections, implementation of these applications must be considered.

Passive technologies:

Partner is requested to investigate passive IPS technologies against customer specifications.

The following technologies shall be investigated (but not limited to):

- Limitation of ice formation capability.
- Limitation of ice accretion capability.
- Limitation of ice shear-off stress.

A first evaluation of endurance (lifetime) of these applications must be considered.

As mentioned in the topic description; ice protection systems investigated in this CFP are dedicated to composite blade ice protection. Any technology not compatible with composite integration (carbon fibre and epoxy resin) shall be highlighted and may be rejected by the customer.

Task 3 : Test criteria and test matrix proposal

Criteria:

Two types of criteria will have to be identified in the IPS analysis:

- Performance criteria: evaluating IPS capability to fulfil its primary function: protection against ice.

- Robustness criteria: evaluating IPS capability to fulfil its secondary function: compliance with all other requirements not specifically dedicated to ice protection (life time, integration, ...).

Partner is requested to define a list of criteria to characterize IPS performance and robustness, and the associated means of compliance. This work will lead to a test matrix proposal.

Ice protection specifications:

- Icing conditions throughout flight envelope must be considered according CS-25 and/or CS-E.

- Maximum mass of accreted ice on test piece: 1.6kg.

- Impact strength: sustain 9.5kJ impact: IPS failure is accepted only on a surface twice the impact surface.

Mechanical specifications:

- Blade surface: 1400*500mm: IPS must cover 20% of chord and 55% to 100% of span. IPS may be split in several pieces to cover the entire surface.

- Acceleration load: acc<9500m/s² (representative of centrifugal force)

- Erosion: test and criteria to be proposed by the supplier to evaluate sand and water erosion (reference is titanium alloy TA6V).

Environment specifications:

- Temperature range: [-55;+120]°C.

- Moisture range: [0;85]%.

- Contamination products: Skydrol ; lubrification oil ; Jet A1 fuel ; MEK (cleaning product) ; Kilfrost (anti-icing product).

Power specifications (if needed):

- Maximum power density on surface: ~10kW/m².

- Average power density on surface: 3kW/m² +/-20%.

Task 4 : Design and manufacturing of test pieces

Partner is required to design and manufacture enough test pieces compliant with:

- Test matrix.

- Test rig.

- Test representativeness

Any test pieces required to develop manufacturing process and controls must be considered by the supplier in addition to the test pieces dedicated to any tests.

This task must be led in parallel with the rig definition task.

Task 5 : Rig test adaptations

Define relevant tests conditions

Partner is required to define relevant icing, mechanical and functional test conditions fulfilling both certification and customer requirements.

Customer will be particularly sensitive to tests conditions representative for icing, mechanical, functional tests (water droplets size and temperature, impact object size and speed, energy supply form etc).

Partner is required to define relevant instrumentation and/or analysis tools to analyse tests results.

Test rig(s) selection:

Partner is required to select one or several test rigs to evaluate IPS functions' performances. Customer will emphasize test rig(s) allowing assessing as much functions as possible (performance and robustness).

The following icing wind tunnel could be considered by the supplier (but not limited to):

- CIRA icing wind tunnel (Italy).
- NRCC icing wind tunnel (Canada).
- DGA-EP icing wind tunnel (France).

Test rig(s) selection adaptation:

Test rig adaptation may be needed to fulfil customer performance and/or robustness testing requirements. This may also be needed to enable multiple functions simultaneous testing.

Partner is required to justify the existing/modified/new rig capacity to demonstrate IPS capability to answer customer specifications.

Customer draws supplier attention to the specificity of rotating bodies protection against ice where mechanical loading has a strong influence. Any rotating test rig may allow high representativeness level.

Test realization and tests results

Partner is responsible for tests preparation (mounting, instrumentation, data acquisition), tests realization, tests analysis. Tests instrumentation will have to approved by the customer.

Partner is requested to deliver all tests data under raw and processed formats.

Partner shall allow customer to attend all tests activities.

Synthesis : Comparison of performance of materials tested , of technologies tested

Partner is responsible for performance and robustness tests analysis, comparison.

Partner is requested to propose a maturation test plan to mature the selected technology up to TRL6.

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

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.

Experience in R&T and R&D programs. Experience of aerospace related research programs would be an advantage. In-house testing capability will have to be emphasized in order to propose an integrated design, manufacturing and testing approach.

Experience in icing test bench design and modification is mandatory.

Experience in the detail design, development, manufacture and validation of ative and/or passive ice protection system technologies would be an advantage.

Availability of test benches to support test campaigns is mandatory.

English langage in mandatory.

Activities shall be conducted using ISO standards.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Implementation plan	Including detailed risk analysis and mitigation proposal	T0 + 1 month
D1	State of the art of materials and technologies		T0 + 6 months
D2	Screening of materials and technologies	Selection of candidates for IPS tests	T0+ 10 months
D3	Test criteria and test matrix proposal	Critical Design Review for rig and test pieces	T0 + 10 months
D4	Design and manufacturing of test pieces		T0 + 20 months
D5	Rig test adaptations	Test Readiness Review	T0 + 20 months
D6	Test realization		T0 + 25 months
D7	Test Results	Data delivery to the customer	T0 + 26 months
D8	Test Synthesis	Comparison of performance of materials and technologies tested.	T0 + 30 months

4. Topic value (€)

The total value of this work package shall not exceed:

€ 2,000,000

[Two Million euro]

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

5. Remarks

Regular phone call meetings (weekly basis) will be held with Topic Manager to deal with technical and program questions.

Face to face workshops will be organized approximately every 4 months on Topic Manager site and/or on test bench site.

Topic Description

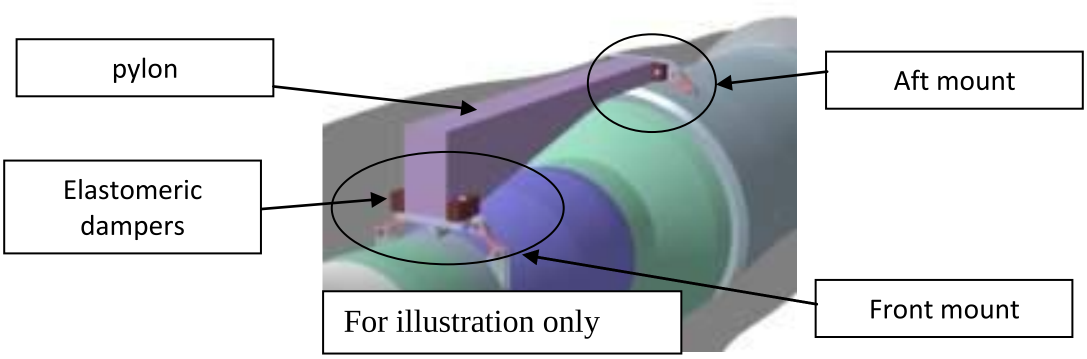
CfP topic number	Title		
JTI-CS-2013-01-SAGE-02-031	SAGE2 Engine In-flight Balancing System	**Start date**	T0
		End date	T0 + 33 months

1. Topic Description

Main goals

The SAGE2 Demonstration Project aims at designing, manufacturing & testing a Counter-Rotating Open-Rotor Demonstrator. It involves most of the best European Engine & Engine Modules & Sub-systems Manufacturers.

The SAGE2 demonstrator will be installed on a pylon located on a test bench (ground tests)



The Engine Inflight Balancing Device and Control System will be designed, manufactured and tested to achieve the following goals:

- To decrease the inflight vibratrions due to propeller unbalances
  - Mechanical unbalance (common unbalance due to geometry of the rotors and blades)
  - Aerodynamic unbalance due to blade to blade pitch mismatch
- Fewer maintenance cost due to trim balancing
- Less vibration level in the Aircraft ➔ more confortable flight for passengers and cabin crew
  - Power management (source+transmission+power needs)
  - Installation (electric power cables, oil feeding, ...) ➔ no oil feeding
  - Environment (Temperature, Chemical, fire proof, electromagnetism, ..)
  - Reliability/ Service life/ Maintenance cost/ accessibility
  - Part sharing ➔ accelerometers+actuators+controller+software

The Main issues to be adressed are :

- Balancing capability consistant with the topic manager's requirements
- Actuators time response ➔ from 1 to 10 sec
- In phase rotor identification (2 counter rotating rotors at same speed) ➔ to be adressed
- Weight ➔ Need balancing capability

Scope of call for proposal

Work Package 0: Management

Time Schedule & Workpackage Description:

– The partner is working 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:

– Quarterly progress reports in writing shall be provided by the partner, referring to all agreed workpackages, technical achievement, time schedule, potential risks and proposal for risk mitigation.

– Monthly coordination meetings shall be conducted via telecom.

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

– The review meetings shall be held at the topic manager's facility.

General Requirements:

– The partner shall work to a certified standard process.

Task list: Engine In Flight Balancing System

Task 1: Balancing system design:

- The partner shall design the engine in-flight balancing system according to the topic manager's requirements,
- The partner shall deliver to The topic manager the data required for Whole Engine Model Dynamic Analysis and engine DMU,
- The partner shall deliver a design justification report,
- The partner shall support the technical review for balancing system architecture approval organized by the topic manager.

Task 2: Balancing system component tests

The partner shall propose a balancing system verification plan including all the relevant component tests. This verification plan will be approved by the topic manager through a technical review.

The partner component test activities shall include:

- Detailed design of test benches and manufacturing or procurement of components based on existing test plan & test bench sketches
- Design and procurement of instrumentation required for the different tests
- Test benches modifications and commissionning including test bench control and instrumentation
- Testing of the relevant parts
- Tests results analysis
- Test results report

Task 3: Balancing system mount system delivery for ground test

The partner activities shall include:

- Manufacturing and/or procurement of the instrumented hardware for engine assembly
- Conformity documents

Task 4: support to ground test (Balancing system)

The partner shall support the topic manager during the ground tests:

- Monitoring
- Measures analysis
- Hardware changes if required by engine dynamic behaviour

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

- Experience in design, manufacturing, testing and certification of aircraft engine in-flight balancing is mandatory
- Experience in elastomeric dampers is mandatory
- Experience in dynamic and vibration engine complex environnement analysis is mandatory
- Experience in test bench design and modification is mandatory
- Experience in endurance tests or other relevant tests contributing to risks abatment is mandatory
- Availability of test benches to support test campaign is mandatory
- English langage is mandatory

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	balancing systems development plan	Including detailed risk analysis and mitigation proposal and a preliminary test pyramid	T0 + 1 month
D2	Balancing system preliminary design substantiation document for Preliminary design review	To check the feasibility and to freeze the architecture and interfaces, to identify the validation plan.	T0+1 months
D3	Design progress reports for balancing systems	Design activities status	T0+7 months
D4	Balancing system detailed design substantiation document for Critical design review	To approve design before hardware manufacturing engagement	T0+13 months
D5	Balancing systems Components Tests benches readiness review	To verify test benches capability to meet validation plan requirements	T0+15 months
D6	Balancing systems Components Tests completed – hardware inspection review	To substantiate mount and balancing systems design	T0+23 months
D7	Balancing system hardware delivery	Engine assembly	T0+23 months
D8	Component Tests reports for balancing systems	To contribute to engine test readiness review	T0+ 29 months
D9	Engine readiness review documentation: - Delivered Hardware status compared - Instrumentation - Test plan requirements	To contribute to engine test readiness review	T0+ 29 months
D10	Engine ground test report for balancing systems	To contribute to engine after-test review	T0+ 33 months

4. Topic value (€)

The total value of this work package shall not exceed:

€ 4,000,000

[Four Million euro]

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

Topic Description

CfP topic number	Title		
JTI-CS-2013-01-SAGE-02-032	Study and durability of electrical insulating material in aircraft engine chemical environment	**Start date**	*T0*
		End date	*T0 + 33*

1. Topic Description

The SAGE2 Demonstration Project aims at designing, manufacturing & testing a Counter-Rotating Open-Rotor Demonstrator. It involves most of the best European Engine & Engine Modules & Sub-systems Manufacturers.

The SAGE2 Demonstrator incorporates two conter-rotating propellers, which should be deiced. An electrical deicing system is studied to supply and transfer the power necessary to the deicing. For this system several type of electrical machines are considered. Each of these machines require organic dielectric materials to provide electrical insulation and avoid electrical discharge to occur.

Beside the harsh temperature conditions that these insulative materials shall withstand, it is also mandatory that they resist to engine fluids such as hyrocarbide lubricant.

The activities of this topic concern the study and durability of typical electrical insulating materials used in the Open-Rotor demonstrator deicing system electrical machine.

The partner shall perfom the following activities, in coordination with the deicing system design study:

Task 1: Project management:

Planning and steering activities for the project.

Quality management of the project.

Task 2: State-of-the-art of organic polymers and interfaces compatibility with hydrocarbide

State-of-the-art report on the organic polymers and interfaces behaviour in hydrocarbide fluids.

State-of-the-art report on the organic polymers and interfaces behaviour studying methods during hydrocarbide fluids ageing.

Task 3: Polymer hydrocarbide ageing test planning

Materials and interfaces process optimisation method

Materials and interfaces ageing behaviour evaluation methods with test parameters

Ageing test plan

Task 4: Material sample and interface test vehicules processing and characterisation

Material process optimisation

Report on optimised material process

Material initial state characterisation

Material interface optimisation

Report on material interfaces process

Material interface intial state characterisation

Task 5: Ageing study

Material ageing behaviour characterisation

Material interface ageing behaviour characterisation

Task 6: Interpretation of test results and recommandations

Material and interface failure mode during hydrocarbide ageing report

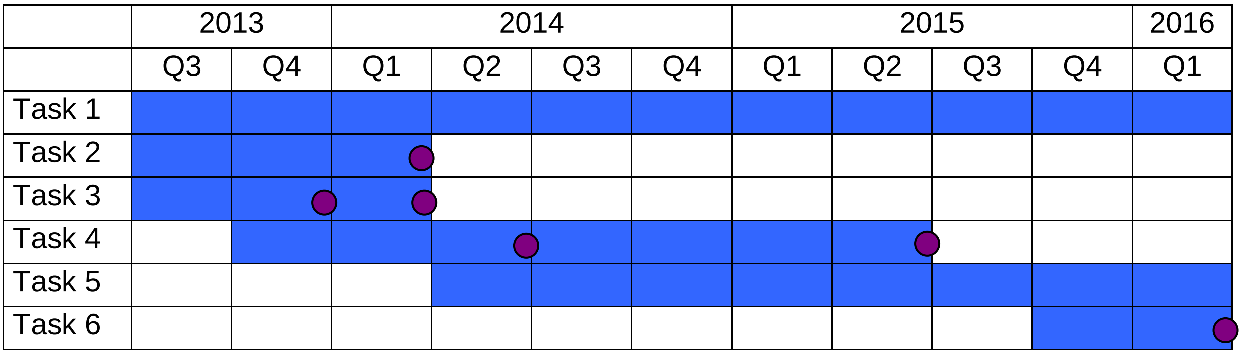
Design recommandation report

Material chemistry optimisation proposal to meet with the requirement or enhance the ageing resistance

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

NB: a consortium of laboratories and/or compagnies may answer the call
Extensive experience in high temperature (above 200°C Tg or Tm) material testing and characterisation
Extensive experience in polymer and there interfaces ageing in hydrocarbide and harsh industrial fluids ageing
Extensive experience in polymer failure mode analysis
Experience in polymer interface testings
Experience in high performance polymer chemistry and synthesis
The applicant should have at disposal equipements and test means for high temperature polymer characterisation and testing
English language is mandatory

3. Major deliverables and schedule



Deliverable	Title	Description (if applicable)	Due date
D1-1	Monthly progress reports		Every month
D2-1	State of the art first report		T0 + 7 Months
D3-1	Test plan and methodology – issue 1 : Material optimisation process method report		T0 + 4 Months
D3-2	Test reports on material tests & analysis on test results and recommendations for task 4		T0 + 7 Months
D4-1	Material sample initial state characterisation report and material sample for ageing study		T0 + 12
D4-2	Material interfaces sample initial state characterisation report and material sample for ageing study		T0 + 24
D5-1	Test results analysis & recommendations		T0 + 32

4. Topic value (€)

The total value of this work package shall not exceed:

€ 500,000

[Five Hundred Thousand euro]

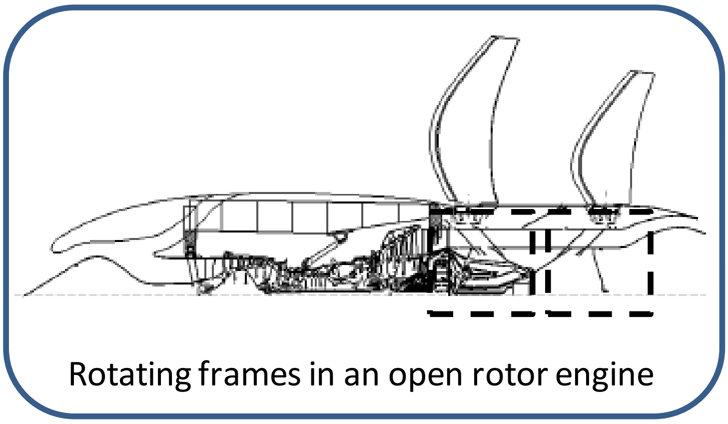
Please note that VAT is not applicable in the frame of the CleanSky program.

Topic Description

CfP topic number	Title		
JTI-CS-2013-01-SAGE-02-033	High speed metallic material removal under acceptable surface integrity for rotating frame	**End date**	*T0 +24 months*
		Start date	*T0*

1. Topic Description

Topic Context

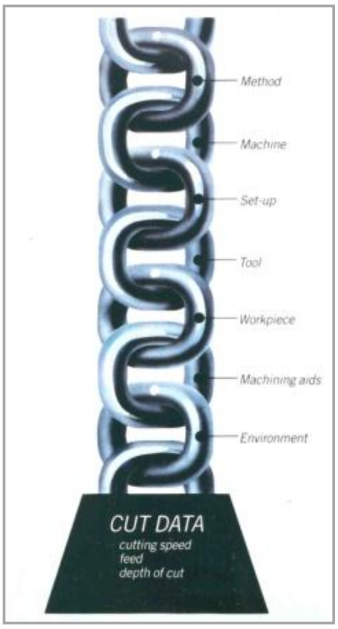


The SAGE project aims at demonstration of engines and technologies to reduce fuel consumtion, weight and increased efficiency of engine components. Within the open rotor development in SAGE2, RTD activities are underway on engine and component development including rotating turbine frames. The rotating frames developed within the SAGE2 project can be considered as engine critical parts, and therefore subjected to corresponding requirements and regulations as such. Structural integrity and safety of engine critical parts have to be considered with regard to design, manufacturing aspects and in-service (maintenance and overhaul). It is currently foreseen that the rotating frames will be made from nickel based precipitation hardening super alloys. In manufacturing, material removal processes with guaranteed good surfaces will be required.

Rapid Removal – From the Manufacturing Perspective

The ever challenging task for production of advanced gas turbine components is to find machining methods and concepts that combines sufficiently high Material Removal Rates (MRR) with required surface integrity. These methods must not only be applicable in terms of robustness but also possible to be applied with care and sense in order to provide a sufficiently high degree of part quality, while still performing at a reasonably low cost. Thus, what is needed can most simply be expressed as a well-defined, highly productive – robust – machining process.

To bring some order to this sometimes hazy description of the machining process and to move focus to the more important facilitating (and at the same time limiting) factors the “link and load” concept may be contemplated.



The main hurdles to overcome, in order to reach a profitable machining application are described next to each link in the chain.

Maximum load – “robust” – “Cut Data” (basically the same notion as Material Removal Rate (MRR)), is limited by the weakest link, such as the machining concept (method), machine tool, stability, cutting tool, work piece, etc.

The definition of (MRR) for conventional machining methods can simply be expressed as **cutting speed** × **cutting feed** × **cutting depth**. Thus, high removal rates are in general synonymous with high speeds and feeds while the cutting depth is usually as limited as possible due, to “near net shape” designs of the raw materials. (Or occasionally limited by the process power, available in the machine).

High speeds and feeds combined can, heavily simplified, be regarded as a machining concept of high energy density and consequently extreme temperatures will be generated at the tool – work interface. It is obvious that the cutting materials must be able to sustain these loads. However, the properties of the work material are equally important (in fact increasingly important) to reach a profitable machining process with high removal rates at expected and required quality.

The proposed work will focus on the work materials and their perceived ability to be machined by "high energy" methods like high speed cutting as well as electro discharge machining, laser cutting and abrasive water jet cutting. In addition, special attention will be set to post machining methods in order to safe-guard the finished surface from any thermally induced anomalies. Thus, a material removal concept will be in focus rather than isolated machining methods.

High Capability Machinability – In the Application Context

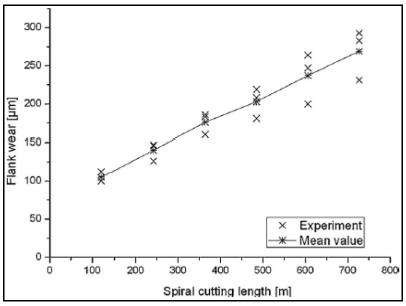
The term machinability is the commonly used denominator to be used to describe how difficult (or easy) a work material will be to machine. The traditional concept of machinability is limited to an index with reference to a standard material and a defined method at a specific wear limit.

And, if needed, an even more universal notion of machinability is simply expressed by the material hardness (number).

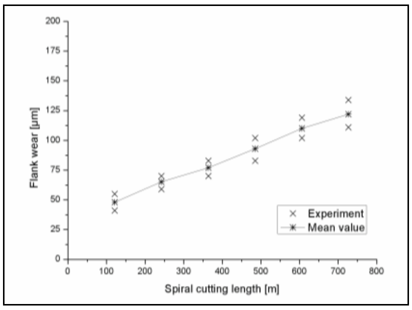
In the materials application context, machinability (as the conglomerate of properties and phenomena just described) may not be the most profound property to pay attention to. Commonly, mechanical strength at elevated temperatures, crack propagation properties and maximum allowable temperature are the first and sometimes only considerations that are made. Leaving production issues to be solved at best practice.

The expected machinability behaviour based on material composition would be that the higher temperature capability of an alloy the more difficult it would be to machine. However, that is not always the case.

Based on previous research and shop experience, machinability expressed in terms of tool wear or tool wear progression does not necessarily follow expected behaviour in terms of e.g. heat resistance.



Graph: Flank Wear IN 718 (turning)



Graph: Flank Wear Waspaloy (turning)

Source: On the Wear Progression in IN718 and Waspaloy
Olovsjö, Wretland, Sjöberg; Wear rates in HRSA; VOLVO Aero Corporation, Internal Work 2008 2010

Thus, in fact and by modern standards machinability is more of a vector than a scalar. The vector can be seen as the previously referenced chain, but in a narrower context (and with clear focus on the work- and tool materials). Therefore, this vector should express all the material properties at hand. In combination with the corresponding description of the machining process (which in fact will be the appropriate transfer function of the process), the process outcome (e.g. MRR) can not only be defined but also predicted.

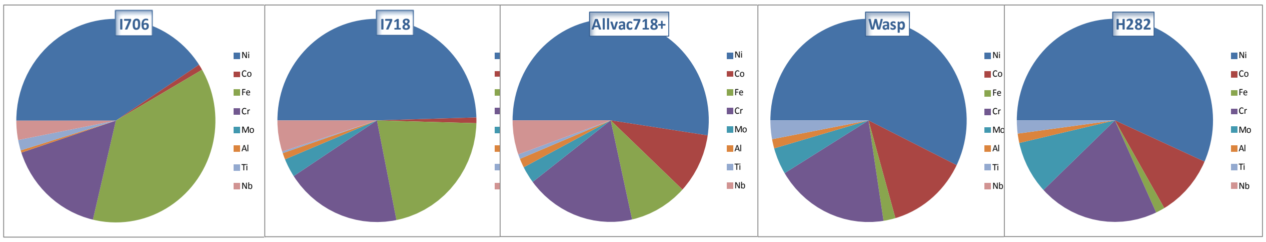
From a generic "method perspective" there are some metal removal methods that are more productive than others. These machining methods range from conventional machining, with and without defined cutting edges (high speed/feed milling and deep feed grinding), to non-conventional methods like high speed electro discharge machining and electro chemical machining.

The common denominator of the high productivity methods is the localized application of energy generated by the process. As consequence, the high temperature properties of the work material (such as high temperature strength and elongation, thermal capacity and conductivity, etc) will have a more profound impact on process capability compared to processes with a more restricted level of energy conversion (e.g. conventional machining methods).

In order to optimize the component the alloys chosen need not to be more advanced than necessary from a design perspective. Thus, a less advanced material like INCO 706 could be chosen over the more capable INCO 718 from an engineering standpoint or the even more advanced HAYNES 282. The gain would be less cost while the risk is unknown production behaviour, in particular at high material removal rates.

The result from previous investigations shows that the expected reduction in machinability of Heat Resistant Super Alloys (HRSA), is not only proportional to properties like strength of materials and thermal conductivity. On the contrary (and what was not expected before the previous investigations were undertaken), the machinability seems more strongly related to the contents of cobalt and iron in the work material than other "technical" properties.

The need to investigate "*High Capability Machinability"* with respect to material properties such as composition and thermal properties is thereby justified. The investigation will be undertaken with reference to alloys with known machining properties, see figure below.



INCO 706 | INCO 718 | Allvac 718+ | Waspaloy | HAYNES 282

Graphs: Contents of various alloying elements in the discussed prioritized super alloys

SAGE – High Capability Rapid Removal

A picture of a typical component (not the actual) to be analyzed can be seen to the right.

All of its design features are not suitable for all metal removal processes with high metal removal rates. Thus, the applicability of such methods to the various components will be studied as an input to the detailed investigation.

Further, process responses in terms of sensor outputs and materials investigations will be studied and where possible correlated.

Finally methods to create a flawless surface in terms of residues from the applied metal removal method or effect from applied thermal and/or mechanical loads will be defined.

Project structure

This CfP topics aims at better understanding manufacturing methods for high speed super alloy material removal to enable an optimum selection of removal processes and optimal selection of process parameters under stringent surface integrity requirements. The work is defined in for distinct blocks:

1. Analyse material removal concepts for a simplified – but relevant - rotating frame design element (see Task 2 below) and select a preferred removal concept. Propose a specific test program.
2. Perform a systematic study of conventional turning and drilling performance versus superalloy composition, (5 commercial alloys). Use conventional turning, drilling and single point boring.
3. Perform machining experiments with high energy non-conventional methods such as electro discharge machining, laser cutting and abrasive water jet cutting – evaluate processes for removing recast layers and other defects generated in the maching process.
4. Prove preferred removal concept by manufacturing a simplified design element by optimum selection of processes and process parameters. Write final assessment report.

Task 1: Management

Organisation:

– The partner shall nominate a team dedicated to the project and should inform CfP Topic manager about the name/names of this key staff. At minimum the responsibility of the following functions shall be clearly addressed: Programme (single point contact with Topic Manager), Engineering & Quality.

Time Schedule & Work package Description:

– The partner shall work to the agreed time-schedule (outlined in Part 3) and work package description.

– The time-schedule and the work package description laid out in this call shall be further detailed as required and agreed during negotiation based on the Partner's proposal.

Progress Reporting & Reviews:

– Monthly one-pager and quarterly progress reports in writing shall be provided by the partner, referring to all agreed work packages, technical achievement, time schedule, potential risks and proposal for risk mitigation.

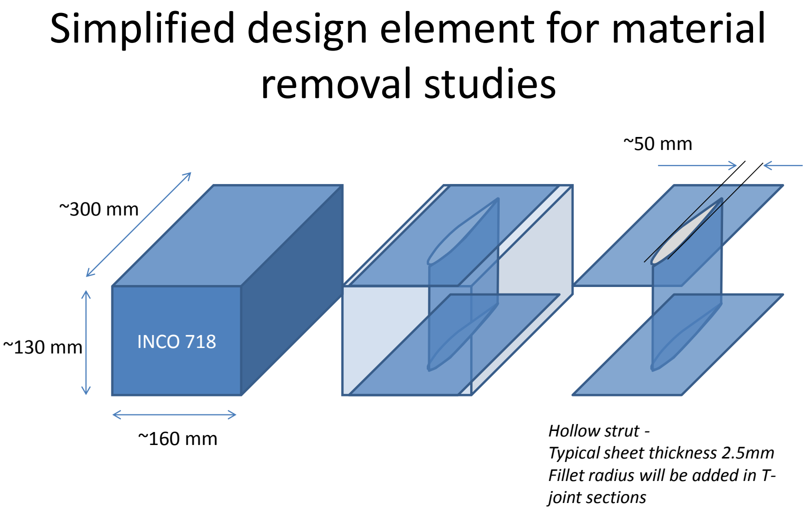
– Regular coordination meetings shall be installed (preferred as telecom).

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

– The review meetings shall be held quarterly by WEBEX, at Topic Manager's premises or at the partner's premises.

Task 2 Rapid removal concept generation

This task will address and analyse a typical jet engine component design feature with relevant geometry, material and surface requirements with respect to material removal – see illustration to the right. The design element will be adequately defined at the start of the project. The baseline material is IN718 but 4 other super alloys should also be included in the study.



The study will result in ranked combinations of material removal processes including possible post treatment for removing and a work plan for creating a database for optimum selection of material removal processes and process parameters for a range of similar super alloy components.

Task 3 Material properties, testing and produceability

This task will focus on the development and execution of relevant practical machining tests (defined in task 2) that can deliver relevant data, to be correlated to the "real" production situation. The main workload that will appear in this task includes ***materials preparation, practical testing*** and ***modelling and simulation*** as primary means for creating understanding, analysing test results and documentation.

Background and Input

An extensive background material (state of the art) from previous investigations and experimental work will be presented by the topic manager (including relevant results from industrial applications).

Method

The practical work will have to comprise at least two types of standard test set ups. These have been in use in the academic research already undertaken as well as the applied industrial work that has been used in order to verify these results in relevant industrial applications. The following areas are expected to be covered.

Material selection and preparation

The materials to be investigated all belong to the HRSA (nickel based) family. They represent a gradual change in composition, where the cobalt content is increasing at the expense of iron. The alloys are (in order of increasing cobalt content) INCO 706; INCO 718; Allvac 718+; Waspaloy and HAYNES 282. To be compatible with the previous work, all test pieces comply with already defined (by the topic manager) conditions regarding heat treatment, grain size and hardness.

The types of material to be tested (conditions) are forged bars (machining). The CfP partner(s) shall provide the material for this task.

Practical machining

The practical machining exercises shall at least comply with previous test procedures. Thus, the primary tests shall be radial turning with predefined cutting data and inserts.

The secondary tests shall be drilling followed by single point drilling. The cutting data, hole geometry and tools for this part of the test campaign are also defined beforehand.

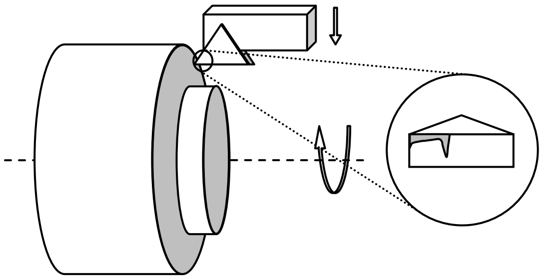
All machined surfaces should be inspected for any defects generated during machining.

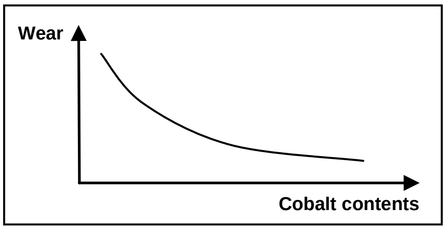
Modelling and simulation

All achieved results shall be documented, preferably in such a way that relevant simulation can be possible. Thus modelling is a vital part of the documentation work. Material properties shall be, when relevant, simulated In J-mat pro or similar software.

Turning

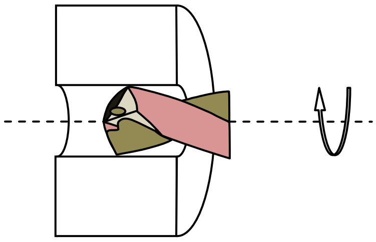
The standard test procedure for turning shall be in accordance with the following sketch.

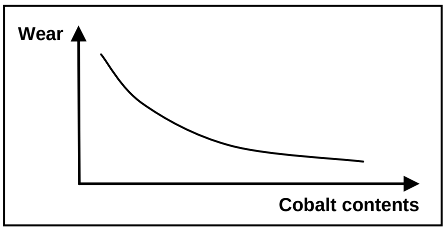




Drilling

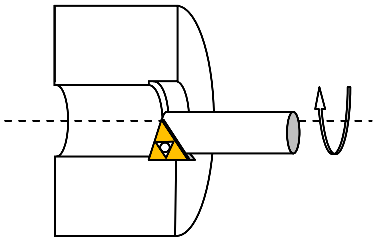
The standard test procedure for drilling shall be in accordance with the following sketch.

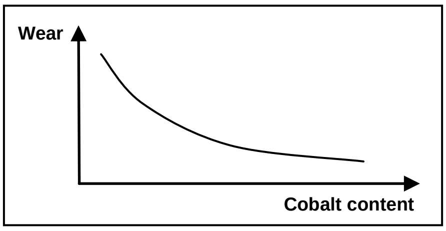




Single Point Boring

The standard test procedure for single point boring shall be in accordance with the following sketch.





Results and Expected Output

The benefit of task 3 is to define the machinability of the mentioned alloys in a wider context to enable optimization of the overall product cost with material quality preserved with respect to process capability and alloy selection. Task 3 will result in a test report with a synthesis section supported by alloy and machining simulation.

Task 4 Surface properties and high energy material removing methods

In this task, methods aiming at specific surface treatment(s) in order to guarantee a surface layer that will not in itself act limiting to the required strength of the material or design, will be defined.

Background and Input

In order to maintain the best material properties a generic production concept for many heavily loaded components start with over seized billets or blanks. As a consequence, large volumes of material have to be removed in order to reach the final shape. A number of the material removal concepts (methods) that are known to have large material removal capabilities are also known to be “hot” methods and thus (possibly) detrimental to the surface. Also when special geometries or cavities are created hot methods may need to be selected for accessibility reasons.

If not detrimental in general terms, they may be specifically detrimental depending on the energy distribution over the cut surface. Thus, related effects like striations and other surface discontinuities needs attention and are to be investigated in this work package.

Method

The three main machining methods in this task are laser beam machining, electro discharge machining and water jet machining.

The processes are to be studied for different alloys, basically the HRSA as for the machining tests. In addition, other suitable alloys for engine applications like titanium, steel. Other alloys may possibly be added to widen the relevance of the study or for giving known references (even aluminium may be considered due to its particular properties - low melting point and relatively low bulk hardness).

The first step of the investigation will be to do a literature survey and list the various defect types and removal concepts. Practical test will then be performed depending on the outcome and ranking of the methods found in the literature survey. IN718 will again be the baseline with the other mentioned heat resistant super alloys to prove generality of the findings. The CfP partner(s) shall provide the material for this task.

Results and Expected Output

The results and expected output from this task are a literature survey and an experimentally proven ranking list of surface treatment methods for electro discharge machining, laser beam and water jet cut surfaces in order not to avoid life diminishing effects on the parts emanating from these surfaces.

Task 5

The last task will produce a demonstrator component according to the illustration in Task 2. The demonstration should be performed with the removal concepts developed in the previous tasks. Machining time for applied processes and surface properties should be recorded as evidence high level proof that the developed data and correlations data can be transformed to industrially relevant knowledge. The topic manager will provide the forged IN718 material for the demonstrator component.

A report referencing the collective results of the project and including a detailed manufacturing sequence list, process parameters and relevant inspection of the component will tie up Task 5.

2. Special Skills Certification or Equipment Expected from the Applicant

Machine Equipment

Work-shop facilities in line with the proposed deliverables (preferably) or, if such equipment is not available, existing relations with institutions or companies that accommodate such equipment. This is in particular the case for grinding machines and the possible need for advanced coolant applications.

Process monitoring equipment will be considered advantageous.

Research Tools

Sensor and data acquisition equipment must be available in line with the proposed deliverables and in particular for the physical units “Force [N]”, “Power [W]” and “Temperature [°C]”.

Experience from metallurgical simulation and manufacturing process simulation is beneficial.

Materials Laboratory

Facilities to perform material analysis (thus, be able to prepare and mount metallographic samples in order to perform optical microscopy investigations of cut surfaces) and (preferably) be able to perform residual stress measurements.

The partner/consortium should preferably hold an “ISO/IEC 17025” certificate.

Communication Requirements

All formal communication within the project must be undertaken in spoken and written English.

3. Major Deliverables and Schedule

Deliverable	Title	Description (if applicable)	Due date
1	Concept selection and ranking of high productivity metal removal methods to jet engine super alloy components	See Task2	M03
2	Work plan for machinability tests and surface removal process tests.	See Task2	M04
3	Literature survey of possible surface defects from high energy removal processes and potential processes for removing them.	See Task 4	M12
4	A produceability test for rapid removal machining methods for a selection of heat resistant super alloys	See Task 3	M15
5	Tests of surface treatment for optimum surface quality of surfaces subjected to high energy material removal processes.	See Task 4.	M17
Milestone 1	Demonstrator component manufactured	See Task 5	M21
6	Final report and documentation of demonstrator component manufacturing-	See Task 5	M24

4. Topic Value (€)

The total value of 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.

Topic Description

CfP topic number	Title		
JTI-CS-2013-1-SAGE-03-021	**TCC Manifold Architecture Parametric Model development**	**Start date**	July 2013
		End date	July 2014

1. Topic Description

Current large Trent engine TCC (Turbine Case Cooling) systems have doubled in weight, cost and complexity driven by desire for a step change in the precision of tip clearance control to enable future shroudless turbine blades.

RTD activities are foreseen for a research organisation to work with an aeroengine customer to develop a parametric computer model which will enable us to develop a generic system model for better optimisation of TCC manifold architecture, located within the core zone a large aero engine.

The TCC system architecture model will develop a system level thermal model for TCC air systems to support architecture down select. This tool will be able to better trade the increasing complexity and weight against the functional benefits, e.g. delivery air temperature versus weight of independent feed ducts.

The trade study will also include mutilple material concepts, alternative architectures and different options for cooling, i.e. independent air feed or segmentation.

The outcome of the CFP topic is to utilise the computer model to provide the customer with sufficient design detail to allow a development standard TCC system to be manufactured and rig tested. The results will enable the customer and partner to validate the computer model for future use in large civil aero engines.

The partner or consortium shall in particular:

Work with the customer to develop a parametric computer system model which will determine type, size and performance of future TCC systems. The proposal should demonstrate how the system model uses aerothermal data to generate recommendations for TCC system architecture.

The proposal needs to also consider manufacturing of the resulting TCC system. In particular how tolerancing issues might effect TCC hardware manufacture. As an improved understanding of tolerance controls improves, the likelihood of delivering producability is increased – i.e. a significant reduction in Non-Quality.

The proposal should also provide an assessment on cost/weight benefits.

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

The partner will have extensive experience in computer software modelling typically in the aero thermal field, and will have demonstrated experience in systems design architecture.

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 and drawings must be made available to the Topic Manager.

Both partner and customer will carry out trials of the software resulting in design work capable of manufacture for rig test validation. Following rig test the partner and customer will jointly review the results and make changes/improvements to the computer model if necessary.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1.1	TCC computer system launch and concept review		July 2013
D2.1	TCC computer system Prelim Design Review		October 2013
D2.2	TCC computer system Critical Design Review		December 2013
D3.1	Launch creation of TCC computer system model for validation testing		January 2014
D3.2	Deliver validation software		March 2014
D3.3	Validation testing		March-May 2014
D4.1	End of validation testing report issued		July 2014

4. Topic value (€)

600,000 €
[Six Hundred 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)

1. A clear and precise budget breakdown should be provided, outlining spend in all areas of the programme (human resource, outsourcing, materials, capital spend, etc.)
2. A detailed Risk Assessment
3. Detailed design and make plan with decision gates and contingency loops

Topic Description

CfP topic number	Title		
JTI-CS-2013-1-SAGE-03-022	**Shared Lubrication Starter system**	**Start date**	July 2013
		End date	April 2015

1. Topic Description

SAGE3 project aims at development and demonstration of a large 3-shaft bypass engine Demonstrator.

Aerospace airframers and customers are pushing for longer service intervals which is highlighting limitations in the service regime for the Air Turbine Starter (ATS). Current civil ATS's require oil changes at 750 hours due to their compact self contained oil sump, whereas airframers want 2000 hours to align with the aircraft A-check. This will become more important for core mounted systems.

Some existing aero engines already use shared lubrication ATS's and this CFP topic is to study the specific configuration implementation and interaction with the oil system of a future large civil aero engine.

The partner or consortium shall in particular:

Carry out an in depth study to review the specific configuration implementation and interaction, of a shared lubrication starter system, with the aero engine's own oil system.

Recommend, design and manufacture a shared lubrication starter system for a large civil gas turbine installation rig test. If the partner feels an engine test is required to validate the modification there is the potential to run a development set of hardware on one of our demonstrator vehicles.

Deliver a detailed cost and weight study to detail the benefits of changing to a shared lubrication starter system.

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

Clear understanding of aero engine oil systems and experience working R&T and R&D programmes would be beneficial.

Extensive experience in the detail design, development, manufacture and validation of ATS's and oil systems.

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 an high technology readiness level to minimise programme risks is a clear advantage.

The Partner or consortium needs to be in the position to have access to the manufacturing facilities suitable for making an agreed subset of hardware for engine test.

The Partner or consortium needs to have access to rig test facilities for oil system, vibration and 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	Shared lubrication ATS system launch and concept review		July 2013
D2.1	Shared lubrication ATS system Prelim Design Review		November 2013
D2.2	Shared lubrication ATS system Critical Design Review		February 2014
D3.1	Launch manufacture of tech demo hardware for		March 2014

	validation testing		
D3.2	Deliver validation hardware		July 2014
D3.2	Shared lubrication ATS system validation rig testing		July-December 2014
D4.1	End of validation testing report issued		April 2015

4. Topic value (€)

500,000 €
[Five Hundred 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)

4. A clear and precise budget breakdown should be provided, outlining spend in all areas of the programme (human resource, outsourcing, materials, capital spend, etc.)
5. A detailed Risk Assessment – key programme, technology, material, manufacturing and budget risks.
6. Detailed design and make plan with decision gates and contingency loops. The plan must include a clear material and feature selection process.
7. The proposal must include details of sub-tier supplier agreements. Lead times for material delivery, quantities, costs, contingencies, etc. should be indicated.
8. Verification of successful manufacture. Requirement to demonstrate in proposal how the Partner would ensure a shared lube starter system is acceptable for useage within an aero engine environment

Topic Description

CfP topic number	Title		
JTI-CS-2013-1-SAGE-03-023	**Microstructure Based Material Mechanical Models for Superalloys"**	**Start date**	*T0*
		End date	*T0+24M*

1. Topic Description

Conventionally the Material Databases in support of component design i.e. with the relevant material allowables within are either decoupled or loosely connected with the microstructures achieved in real components. This is particularly true of "well established" materials, which are used across a wide variety of components and therefore, show a wide range of microstructures.

This situation has far reaching implications. In fact, for the design activity to be robust, it shall be consistent with the minimum material capability i.e. that resulting from the "worst" acceptable metallurgy. This thus, results in non-competitive designs in terms of weight and cost.

The development and validation of a microstructure, defectology and surface condition sensitive material model, able to predict the mechanical behaviour and design allowables for a given microstructure&defectology, enables further design improvements as it will pursue matching "real" material capability with the microstructures within components. Turbine static components within the last build of the SAGE-3 Demonstrator will be the object of this further mechanical optimization i.e. casings and structures (Tail bearing housing, seal panel etc.).

The microstructural features which are potentially relevant from a mechanical standpoint are among others: the distribution of grain sizes, hardening particles, precipitates and other phases etc.. The contribution of process specific; i.e. casting and wrought/forging related, defectology such as shrinkage, porosity , inclusions, light etching features etc. as well as the resulting surface condition are also relevant inputs to the material capability of gamma' and gamma" containing Nickel Base Superalloys. The material mechanical model should therefore, consider their contribution.

This exercise shall bring the opportunity to match microstructures&defectology with a variety of mechanical properties used in the design of components i.e. tensile, LCF, HCF, crack prop, fracture toughness and creep for working temperatures ranging from Room Temperature up to 700ºC.

Although with a reasonable phenomenological base, this Call for Proposal might require deepening into the micromechanical aspects to finally build a "macro" model which shall also pay attention to statistical aspects.

The objective of this call for proposal is to develop and validate a microstructure, defectology and surface condition sensitive material mechanical model for gamma' and gamma" containing Nickel Base Superalloys in its both material forms; i.e. casting and wrought/forging. The activities within this Call for Proposal in combination with other attempts conducted to predict the outcome in terms of the final metallurgy for both raw material manufacturing processes shall allow matching design requirements with process capability.

This proposal shall review and analyse existing experience with regards to material capability for a range of microstructures, defects and surface conditions as well as combinations thereof. This together with potentially ad-hoc testing shall help identifying the relevance of various and competing deformation&failure mechanisms as well as the prevailing ones with a view to predict the mechanical behaviour of the material within components. The technology developed hereby shall be validated with previously generated experience at specimen level which has so-far been to input component design.

Find it hereby a breakdown of activities within the project:

- Identification of mechanically relevant material features, microstructure, defectology and surface condition on both forms of material
- Microscale Mechanical characterization; singled out vs. combined effect of the relevant features
  – Models for homogeneous materials
  – Models for heterogeneous materials
- Characterization of the microstructure on already tested specimens
  – Volume and size effects
  – Probabilistic approach

Generation of deterministic and stochastic rules for the derivation of mechanical allowables for properties in support of component design

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

The Applicant shall have a sound background on physical metallurgy. At such, it shall have a thorough understanding with regards to the relationships between microstructure and mechanical properties. To this end, a previous knowledge insofar as the relevant deformation&failure mechanisms under the relevant working conditions will be valued.

The Applicant shall bring to the Consortium any relevant testing capabilities in either of the two following lines

At Microscale level, i.e. valid for the size range (1–1000 microns). Any proposed technique for mechanical characterization shall allow the coverage of temperatures relevant to the end user application i.e. from Room Temperature up to 700ºC. The proposed techniques shall allow also either directly or indirectly correlate the results obtained with technologically relevant mechanical properties for component design i.e. i.e. tensile, LCF, HCF, crack prop, fracture toughness and creep rupture and creep strain.

With regards to the mechanical characterization at specimen level, the applicant shall have or have access to laboratory testing facilities necessary for assessing the metallurgical condition and mechanical behaviour at specimen level. For this the usage of NADCAP approved Labs. will be rq´d.

The applicant shall have capabilities to analyse the metallurgical condition on samples across volume and to derive statistically relevant information insofar as their microstructures. The applicant shall also be able to identify the competing deformation&failure mechanisms and the potential interactions with the relevant features in terms of microstructure, defectology and surface condition.

The applicant shall be able to post process and integrate mechanical and metallurgical info generated at various scales i.e. micro and meso. It shall be able to account for any size/volume effect to the point to deliver a validated model for the prediction of mechanical properties at component level. This technology shall come along the two lines i.e. deterministic and stochastic multiscale analysis. Previous experience in the field and modelling capabilities will be valuable.

3. Task Description

Full duration of the project: 2 years

Work Package (WP) Description and Deliverables (if applicable)

<u>Task 1: Management.</u>

Duration: 24 months

Organisation:

– The partner shall nominate a team dedicated to the project and should inform the Project Manager about the name/names of the key staff. At least the responsible persons for following functions shall be identified; Program (single point of contact), Technical and Quality

Time Schedule and Planning:

– The partner shall be working 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 and reviews:

– Monthly progress reports in writing shall be provided by the partner, referring to all agreed Work Package, technical achievement, time schedule, potential risks and proposal for risk mitigation

– Regular coordination meetings shall be setup (preferably via telecom of through web link)

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

– The review meetings shall be held in a location to be designated

Progress, reporting and reviews:

– Monthly progress reports in writing shall be provided by the partner, referring to all agreed Work Package, technical achievement, time schedule, potential risks and proposal for risk mitigation

– Regular coordination meetings shall be setup (preferably via telecom of through web link)

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

– The review meetings shall be held in a location to be designated

Task 2: State of the Art and, review of existing experience and definition expected outputs

Duration: 1 month

This Task shall focus on the compilation of similar attempts made in the Literature. It shall highlight its overall feasibility and potential risks in view of the existing experience. A detailed proposal will follow based upon the existing experience; i.e. relevant combinations in terms of microstructure, defectology and surface condition in components altogether with the results of mechanical tests which might already exist for some of them.

This WP shall highlight the detailed activities to be conducted within Work Packages 3 to 5; i.e total number and type of additional tests needed at the various scales, degree of metallurgical analysis required as well as the degree of validation work needed.

Task 3: Generation of a preliminary mechanical model at the relevant scale.

Duration: 12 months

This Task will deliver a preliminary mechanical material model, accounting for various scenarios in terms of microstructure, defectology and surface condition. Within this WP either material already available or additional material, which might need to be manufactured within the Project, will be tested at the appropriate scale.

This model shall input further technology developments taking place at specimen level within Task 4. These might account for the potential interactions between various material domains in terms of microstructure, defectology and surface combination.

Task 4 ; Generation of a model at Specimen Level

Duration: 9 months

This Task shall allow the generation of a model able to predict the mechanical behaviour at specimen level and to account for the various sources of statistical variability in terms of mechanical properties within the existing material database. This Task shall allow understanding and working out the potential contribution of each effect in isolation as well as its integrated effect.

Task 5 Model Integration and Implementation at component level

Duration: 9 months

This Task will integrate the technologies developed within WP Nos. 3 and 4 together with the existing mechanical test data.

A mathematical model shall be generated able to deterministically predict the material allowables within components. Additionally, a probabilistic model shall be generated which shall pay specific attention to surface and volume effects as well as any other relevant scale factor.

Within this Task, the contribution of the Project Manager shall be sought with regards to the expected microstructure, defectology and surface condition within either Forgings or Castings. This will be based upon existing manufacturing experience and potentially the input from existing Process Modelling tools. The output from this task shall allow generating material allowables in the required format (output) so that they can be subsequently used per the existing CAD and CAE tools..

4. Main deliverables and schedule

Task	Deliverable	Title	Due Date
1	**Management**		
	Various	Management Meetings	Every Month
	Various	Proggress Meetings	Every 6 Months
2	**State of the Art**		
	2.1.-	State of the Art, existing experience and expected outputs	T0+1M
3	**Preliminary Mechanical Model at the relevant scale**		
	3.1.-	Preliminary Mechanical Model; Tensile	T0+9M
	3.2.-	Preliminary Mechanical Mode; Fatigue	T0+9M
	3.3.-	Preliminary Mechanical Model; Crack Prop	T0+12M
	3.4.-	Preliminary Mechanical Model; Creep Strain and Creep Rupture	T0+12M
4	Mechanical Model at Specimen Level		
	4.1.-	Mechanical Model Specimen Level; Tensile	T0+15M
	4.1.-	Mechanical Model Specimen Level; Fatigue	T0+15M
	4.1.-	Mechanical Model Specimen Level; Crack Prop	T0+18M
	4.1.-	Mechanical Model Specimen Level; Creep Strain and Creep Rupture	T0+18M
5	Model Integration and Implementation		
	5.1.-	Material Mechanical Model; deterministic	T0+21
	5.2.-	Material Mechanical Model; probabilistic	T0+24

Task No.	Description	Year 1				Year 2			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	**Management**								
2	**State of the Art, review of existing experience and expected outputs**								
3	**Generation of a preliminary mechanical model at the relevant scale**								
	Static Properties; Tensile								
	Fatigue								
	Crack Prop								
	Creep								
4	**Generation of a model at Specimen Level**								
	Static Properties; Tensile								
	Fatigue								
	Crack Prop								
	Creep								
5	**Model Integration and Implementation at Component Level**								
	Deterministic								
	Probabilistic								

5. Topic value (€)

The total value of this work package shall not exceed

€ 850,000

Eight Hundred and Fifty Thousand euro

Note a portion of the whole sum shall be dedicated to mechanically test some existing material so that some of the mechanical gaps as specimen level are filled up. An estimate of this sum is around 100.000€.

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

Topic Description

CfP topic number	Title		
JTI-CS-2013-1-SAGE-03-024	**Electric Pump for Safety Critical Aero engine applications**	**Start date**	June 2013
		End date	Dec 2014

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 a electrically driven pumps to replace traditional mechanically driven variants in engine externals. The objective of the work package 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 would be advantageous for the partner to consider how the unit could be designed to operate in various locations within the engine, eg. Core or fancase mounted with the associated implications in vibration and temperature environment.

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

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 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 mechanically ganged multi-element gerotor based pumps driven through permanent magent electrical motors, the partner will be expected to consider alternative solutions for each technology area. Strategies to ensure the correct syncronisation between individual pumping elements (eg. Between feed and scavenge in the oil application) should also be addressed

The Partner will provide a detailed verification proposal for the new pump. The solution should be demonstrated to TRL6 (i.e. in an environment representative of an engine installation) and proposals should 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 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 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.

Task 3: Electrically driven pump validation support

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

Typical Electric oil pump operating environment

Temperature

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

Vibration

Consideration should 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 an 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	June 2013
D1.2	Electric oil pump technical specification	Agreed specification against which to continue project	Sept 2013
D2.1	Electric oil pump Prelim Design Review		Dec 2013
D2.2	Electric oil pump Critical Design Review		April 2014
D3.1	Launch manufacture of tech demo hardware for validation testing		Oct 2014
D3.2	Deliver validation hardware		Nov 2014
D3.2	Validation testing		During 2014
D4.1	End of validation testing report issued		Dec 2014

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

<u>Content of the proposal (including these items will significantly enhance the proposal)</u>

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 useage within the engine conditions listed.

g) The partner should identify key certification drivers from appropriate regulatory bodies (eg. 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.

Clean Sky Joint Undertaking
SP1-JTI-CS-2013-01-SAGE-03-025

Topic Description

CfP topic number	Title		
JTI-CS-2013-1-SAGE-03-025	**Variable fluid metering unit for Aero engine applications**	**Start date**	June 2013
		End date	Dec 2014

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 an electrically driven solution to replace traditional mechanically driven variants of engine externals. Part of this implementation is likely to include a variable metering unit to control fluid delivery into specific areas of the engine. The objective of the work package is to develop this technology and demonstrate to Technology Readiness Level (TRL)6.

Media typical of requiring this functionality can include fuel, oil and other fluidic substances depending on the engine application. For the purposes of exploring the viability of varaible metering solutions, engine oil is chosen as the candidate fluid for this demonstration.

It would be advantageous for the partner to consider how the unit could be designed to operate in various locations within the engine, eg. Core or fancase mounted with the associated implications in vibration and temperature environment.

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 variable metering unit

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 as appropriate for a variable oil metering unit suitable for controlling the delivery of oil into individual regions of a large civil engine.

The Partner is expected to recommend new and novel configurations and will preferably demonstrate how the unit along with any associated drive components will interface to an Electronic Engine Controller. Whilst initial investigations into this technology have considered electro-hydraulic servo valve based configurations as a potential solution, the partner will be expected to consider alternative solutions for this technology.

The Partner will provide a detailed verification proposal for the new unit. The solution should be demonstrated to TRL6 (i.e. in an environment representative of an engine installation) and proposals should 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: Variable Metering unit 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 metering unit and support design and manufacturing technology.

It is expected that demonstration of the variable metering unit 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 validation.

Task 3: Variable Metering unit validation support

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

Typical Variable Metering Unit operating environment

Temperature

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

Vibration

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

Oil Metering

The variable metering unit controls a flow of oil to the Engine components for cooling and lubrication with typical flow rates, temperatures and pressures included in the following table:

Typical Metering Flow Parameters			MHD MTO Nominal Requirement	ISA MTO Nominal Requirement
Inlet conditions				
Inlet temperature		ºC	172	152
Inlet Pressure (max)		psia	332	360
Nominal Metered 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

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.

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 an 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	Variable Metering Unit launch and concept review	Participate in launch review for project	June 2013
D1.2	Variable Metering Unit technical specification	Agreed specification against which to continue project	August 2013
D2.1	Variable Metering Unit Prelim Design Review		October 2013
D2.2	Variable Metering Unit Critical Design Review		Dec 2013
D3.1	Launch manufacture of tech demo hardware for validation testing		Jan 2014
D3.2	Deliver validation hardware		May 2014
D3.2	Validation testing		During 2014
D4.1	End of validation testing report issued		Dec 2014

4. Topic value (€)

750,000 €
[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 useage within the engine conditions listed.

g) The partner should identify key certification drivers from appropriate regulatory bodies (eg. 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-2013-01-SAGE-04-20	**Development of a robust forging process for a new advanced aero-engine rotor material**	**Start date**	*T0*
		End date	*T0 + 24M*

1. Topic Description

A first generation of geared turbofan engine (GTF) technology has found its way into the regional and narrow body market due to significant reductions in fuel consumption and noise compared to conventional turbo fan engines.

The purpose of the advanced geared turbofan demonstrator as part of the Sustainable and Green Engine (SAGE) platform is to further advance these technologies and to achieve a next step change in fuel burn reduction combined with an additional decrease in noise emission. Components and modules with new technologies are to be developed, implemented and validated through rig testing as required before integration into a donor engine and SAGE4 full engine demonstration. The successful validation of technologies for this aircraft engine concept will then facilitate the early introduction of innovative new products into the market, and significantly reduce the environmental impact of air transport.

In order to answer the needs of the SAGE4 geared turbofan in terms of research, technological development and demonstration activities, it is planned to offer individual tasks to the industry, universities or any legal entity. Therefore, the present Call for Proposal supports the further development of materials with a high optimization potential to allow alternate designs of environment-friendly aero-engine components.

Temperatures e.g. in advanced engines are borderline for currently used materials and are expected to rise even further. Therefore from a technical point of view a material with enhanced high-temperature capability compared to the currently used DA718 will be required for the first rotor stage(s) applications in the LPT of new engines.

The objective of the call is the industrial implementation of a pre-developed high-temperature nickel-based alloy (ingot metallurgy) for disk applications in aero-engines with characteristics comparable to the alloys U720LI accompanied with a considerable cost reduction compared to U720LI.

The environmental benefit shall be an increase of up to 50% of the production process yield for the billet material compared to U720LI. Consequently the energy per ton of usable raw material will be reduced by up to 50%. Furthermore the envisaged improvement of high temperature capabilities would allow an increase in efficiency of the engine.

Based on the given requirements, the partners work includes the following tasks:

Task 1: Management

Organisation:

- The partner shall nominate a team dedicated to the project and should inform the topic manager about the name/names of this key staff. At least the responsibility of the following functions shall be clearly addressed: Program (single point of contact with the topic manager), Techniques & Quality.

Time Schedule & Work package Description:

- The partner is working 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:

- Quarterly progress reports in writing shall be provided by the partner, referring to all agreed work packages, technical achievement, time schedule, potential risks and proposal for risk mitigation.
- Regular coordination meetings shall be installed (preferred as telecon).
- The partner shall support reporting and agreed review meetings with reasonable visibility on its activities and an adequate level of information.
- The review meetings shall be held in the topic manager´s facility.

General Requirements:

- The partner shall work to a certified standard process.

Task 2: Development of a melting process at minimum cost (using revert material) for production of ingots

The proposer presents thermodynamic calculations and first trial results (if applicable) proving the capability of the proposed alloy composition. The method of manufacturing for the melting process including the limits for revert material shall be provided to the topic manager. The capability of future process up scaling can be assured.

Task 3: Development of a conversion process at minimum cost for production of billets

The method of manufacturing for conversion shall be provided. The chemical composition at different locations (top/bottom) in the billet as well as the microstructure of the cross-section is evaluated. The results shall be sent to the topic manager for review. As part of the quality assurance concept the converted material shall be inspected by ultrasonic testing in order to detect flaws and/or inclusions in the material. The requirements for ultrasonic testing shall be according to AMS2154 (No. 2 FBH for diameter smaller 254mm). The capability of future process up-scaling can be assured by the proposer.

Task 4 : Development of a forging and heat treatment process for production of raw parts

A forging contour of a disk is defined together with the topic manager. The forging simulation shall be presented within the scope of the pre-production readiness review. The simulation shall include the grain flow which is required for defining the ultrasonic testing instruction. Also the temperature, strain and strain rate distribution in the disk are part of the simulation. Based on this simulation a prediction of the microstructure will be calculated.

The method of manufacturing for forging including the heat treatment procedure shall be provided. A process up-scaling to larger disks is feasible.

Task 5 : Evaluation of microstructure, mechanical properties and internal flaws

A detailed cut-up plan including all test locations is prepared by the proposer and approved by the topic manager.

This scheme refers to metallographic investigations (macro- and microstructure, on-part micros) as well as to the evaluation of mechanical properties (room temperature/hot tensile, fatigue tests, stress rupture test, creep tests, fracture toughness, fatigue crack propagation tests). The number of specimens per test shall allow a statistic validation.

Ultrasonic inspection of the forging shall be performed following an instruction procedure provided by the topic manager.

All tests and inspections shall only be performed by NADCAP or approved suppliers or facilities.

Task 6: Analysis and substantiation of total billet production cost

- Detailed cost analysis for melting and conversion process is prepared
- Cost reduction compared to U720LI is evaluated.
- Further cost savings potentials are identified for up-scaled production

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

- Experience in ingot metallurgy for production of raw material for aero engine disk applications.
- Capability to forge critical parts for aero engine disk applications.
- NADCAP or in-house approved heat treatment process at topic manager.
- Capability to involve certified material test houses for specimen tests.
- Capability to involve certified ultrasonic test houses.
- Capability of pre-machining of forgings.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Detailed Project Plan	schedule with milestones, technical specification of process and equipment	T0 + 1M
D2	Development of a melting process	Development of a melting process at minimum cost → Method of manufacturing	T0 + 6M
D3	Development of a conversion process	Development of a conversion process at minimum cost → Method of manufacturing	T0 + 9M
D4	Development of a forging and heat treatment process	Simulation and Die-forging contour definition; method of manufacturing for forging and heat treatment	T0 + 12M
D5	Evaluation of microstructure, mechanical properties and internal flaws	Cut up plan and report about material properties	T0 + 24M
D6	Analysis and substantiation of total billet production cost	Cost analysis and comparison to reference material Udimet720LI	T0 + 24M

4. Topic value (€)

1,000,000 €
(One Million 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.

5. Remarks

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.

Clean Sky Joint Undertaking
SP1-JTI-CS-2013-01-SAGE-04-021

Topic Description

CfP topic number	Title		
JTI-CS-2013-01-SAGE-04-21	Development of an advanced forging process for optimised turbine casing material	**Start date**	T0
		End date	T0 + 14M

1. Topic Description

A first generation of geared turbofan engine (GTF) technology has found its way into the regional and narrow body market due to significant reductions in fuel consumption and noise compared to conventional turbo fan engines.

The purpose of the advanced geared turbofan demonstrator as part of the Sustainable and Green Engine (SAGE) platform is to further advance these technologies and to achieve a next step change in fuel burn reduction combined with an additional decrease in noise emission. Components and modules with new technologies are to be developed, implemented and validated through rig testing as required before integration into a donor engine and SAGE4 full engine demonstration. The successful validation of technologies for this aircraft engine concept will then facilitate the early introduction of innovative new products into the market, and significantly reduce the environmental impact of air transport.

In order to answer the needs of the SAGE4 geared turbofan in terms of research, technological development and demonstration activities, it is planned to offer individual tasks to the industry, universities or any legal entity. Therefore, the present Call for Proposal supports the further development of materials with a high optimization potential to allow alternate designs of environment-friendly aero-engine components.

Modern aero engine concepts require high performance materials which are able to operate under extreme thermal and mechanical conditions. ATI 718Plus® is a novel nickel base alloy developed and produced exclusively by ATI Allvac. The alloy was recently qualified and introduced in the materials portfolio of the topic manager for use in forged LPT casings. Due to the optimized temperature stability of this alloy, casings in ATI 718Plus can operate at higher temperatures than with today's standard material Inconel 718. This offers an option to increase turbine gas temperatures and to reduce cooling air. Both aspects contribute significantly to the overall module efficiency.

The producibility of large forgings like turbine casings in ATI 718Plus alloy was investigated in the past by several US forgers in collaboration with the alloy producer, jet engine manufacturers and university institutes. It turned out that the material properties resulting from the microstructure formed during the forging process highly depend on the forging parameters and subsequently applied heat treatments. Further investigations need to be done in order to reduce microstructure variations in parts and batches and to optimize the material properties with regard to tensile strength, creep and LCF capability.

As announced by the alloy supplier, ATI 718Plus should have a maximum service temperature of 700°C. During long-term exposure above this temperature limit, changes to the alloy's microstructure occur, which lead to a deterioration of the material properties. However, it was found that after 300-1000 hours of exposure at 700°C, especially the creep strength of 718Plus can be highly affected by overaging effects or phase transformations. This effect could be reduced by selecting appropriate forging and heat treatment parameters in order to make the microstructure more stable against overaging effects occurring during long-term exposure at 700°C.

The cost of forged parts is mainly driven by the raw material and the work input added by the forger. Due to the low experience level with ATI 718Plus, most forgers quote the work input for 718Plus casings higher than for Inconel 718 casings. However, it was already shown in earlier forging trials that

ATI 718Plus can be forged with a work input at least comparable to standard Inconel 718. Modifications to the forging process parameters might be necessary in order to produce 718Plus casings leading to cost/price levels equivalent to Inconel 718.

718Plus® is a registered trademark of ATI Allvac.

Based on the given requirements, the partners work includes the following tasks:

Task 1: Management

Organisation:

- The partner shall nominate a team dedicated to the project and should inform the topic manager about the name/names of this key staff. At least the responsibility of the following functions shall be clearly addressed: Program (single point of contact with topic manager), Techniques & Quality.

Time Schedule & Work package Description:

- The partner is working 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:

- Quarterly progress reports in writing shall be provided by the partner, referring to all agreed work packages, technical achievement, time schedule, potential risks and proposal for risk mitigation.
- Regular coordination meetings shall be installed (preferred as telecon).
- The partner shall support reporting and agreed review meetings with reasonable visibility on its activities and an adequate level of information.
- The review meetings shall be held in the topic manager´s facility.

General Requirements:

- The partner shall work to a certified standard process.

Task 2: Collect available information and defined project plan

- A broad base of scientific investigations, forging and heat treatment recommendations on ATI 718Plus alloy is available in the open literature. Unless not already available, the applicant should make himself familiar with these information.
- Based on his own experience and the collected information the applicant should create a detailed test plan for the task defined above.

Task 3: Optimize forging process

- The manufacturing process for turbine casings in ATI 718Plus should be optimized.
- The following parameters can be modified (list not exhaustive):
  - forging temperature during rolling steps
  - number of reheats
  - number of grinding operations
  - forging end temperature
  - solution heat treatment conditions
  - precipitation heat treatment conditions
- The aims of the optimization are defined as follows
  - reduce forging cost while maintaining material properties
  - minimize microstructure/material property variations in single parts and in multiple part batches
  - optimize material properties (tensile, creep and LCF) related to the microstructure

- optimize temperature capability of the alloy (tensile and creep up to 1000 hours exposure at 700°C)

- avoid embrittlement of the material

- Three prototype casings should be forged with the optimized parameters. One part should be used for the specimen tests. Further two parts have to be delivered to the topic manager for demonstration and validation purposes.

Task 4: Test specimens

- Test specimens to perform metallographic analysis, tensile, creep and LCF tests should be cut from the forged and fully heat treated parts. The tests should be conducted at 700°C, for tensile additionally at room temperature. Charpy impact test at low and elevated temperatures should be conducted to check brittleness of the material.
- Additionally, testing of material that was overaged at 700°C for 300 and 1000 hours should be performed in the same way as described before (no LCF).

Task 5: Report results

- The results of the forging parameter optimization and the specimen tests should be reported in an appropriate form.
- The raw material data resulting from the specimen tests should also be transferred.

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

- Capability to perform ring rolling and/or turbine case forging. High expertise required.
- Capability to perform heat treatments or to involve certified partners.
- Capability to cut test specimens from forged and fully heat treated parts.
- Capability to perform metallographic analysis or to involve certified material test institutes.
- Capability to perform specimen tests (tensile, creep, Charpy impact) or to involve certified material test institutes.
- The partner should highlight the industrial capacity to further develop, optimise, certify and produce turbine casings in ATI 718Plus under commercial conditions.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Detailed Project Plan	schedule with milestones, technical specification of process and equipment	T0 + 1M
D2	Risk Mitigation Plan		T0 + 1M
D3	Proposal for optimised forging process	Development and test of forging process for ATI 718Plus casings	T0 + 6M
D4	Test results and raw data from specimen tests	Perform and evaluate material tests (metallography, tensile, creep, LCF, Charpy impact)	T0 + 12M
D5	Three prototype parts	One prototype part used for specimen tests; Two prototype parts for demonstration and validation purposes	T0 + 14M
D6	Report	Report of production parameter optimization and test results	T0 + 15M

4. Topic value (€)

600,000 Euro (Six Hundred 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.

5. Remarks

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-2013-01-SAGE-04-22	Development of an advanced long life Ceramic Matrix Composite (CMC) turbine component	**Start date**	*T0*
		End date	*T0 + 24M*

1. Topic Description

A first generation of geared turbofan engine (GTF) technology has found its way into the regional and narrow body market due to significant reductions in fuel consumption and noise compared to conventional turbo fan engines.

The purpose of the advanced geared turbofan demonstrator as part of the Sustainable and Green Engine (SAGE) platform is to further advance these technologies and to achieve a next step change in fuel burn reduction combined with an additional decrease in noise emission. Components and modules with new technologies are to be developed, implemented and validated through rig testing as required before integration into a donor engine and SAGE4 full engine demonstration. The successful validation of technologies for this aircraft engine concept will then facilitate the early introduction of innovative new products into the market, and significantly reduce the environmental impact of air transport.

In order to answer the needs of the SAGE4 geared turbofan in terms of research, technological development and demonstration activities, it is planned to offer individual tasks to the industry, universities or any legal entity. Therefore, the present Call for Proposal supports the further development of materials with a high optimization potential to allow alternate designs of environment-friendly aero-engine components.

Ceramic Matrix Composites (CMC) (e.g. SiC/SiC) provide a 3 times lower specific weight than superalloys. So they can significantly contribute to the weight reduction of aero engines.

The SiC/SiC material shows significant loss of strength by oxidation of the fibres and the matrix above 700 °C. which is reached for all stages of the LPT depending on the load case. The durability for the CMC parts must exceed at least more than 10000 hours.

The objective of the call is the development of a component segment with proven protection coating for the SiC/SiC – CMC material with enhanced durability .

Based on the given requirements, the partners work includes the following tasks:

<u>**Task 1: Management**</u>

Organisation:

- The partner shall nominate a team dedicated to the project and should inform the topic manager about the name/names of this key staff. At least the responsibility of the following functions shall be clearly addressed: Program (single point of contact with topic manager), Techniques & Quality.

Time Schedule & Work package Description:

- The partner is working 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:

- Quarterly progress reports in writing shall be provided by the partner, referring to all agreed work packages, technical achievement, time schedule, potential risks and proposal for risk mitigation.

- Regular coordination meetings shall be installed (preferred as telecon).
- The partner shall support reporting and agreed review meetings with reasonable visibility on its activities and an adequate level of information.
- The review meetings shall be held in the topic manager´s facility.

General Requirements:

- The partner shall work to a certified standard process.

Task 2: Process development of SiC/SiC CMC with coupons

The steps of the material development should be described in detail. A risk management plan for the trails must be incorporated in the description of the work package. The connection of the planned refinement trails and the time schedule must be highlighted. The number of test coupons should satisfy the confidence requirements for an aero engine test run.

- Optimization of a protection coating for SiC/SiC materials to engine environment (hot gas, temperature, etc.)
- Tensile and bending strength of minimum 200 MPa under aged condition has to be guaranteed for all test conditions.
- Material data evaluation based on coupon test (Thermo physical data (lambda, alpha, E, G-Module), static strength, low cycle fatigue, high cycle fatigue, creep thermo mechanical fatigue). Relevant material data shall be provided either by a defined test program or by qualified material data base of former activities.
- Evaluation of material data of un-aged and aged test specimen at room temperature and 3 elevated temperatures (max. 1050K - 1123K).
- The way to Industrialization of the process should be highlighted

Task 3: Design of a CMC component segment with protection coating

The work on the design of a CMC component segment with suitable protection coating should include the coatings of the fibre and coating of the material. The material must be manufactured within given tolerances and dimensions. The production process must cover a production rate of an average number of 5.000 – 10.000 parts p.a (size of 100 mm x 30 mm).

All process steps should to be proved with suitable digital measurement methods at certified measuring devices. The required finishing operations (grinding, etc.) should be performed by the proposer or a qualified and certified subcontractor.

A time schedule for the development of the protection layer should include sufficient attemps for achieving the specified quality standard of the part. The type of the refinement action (for example: variation of manufacturing parameters, change of chemical formation) should be highlighted in the schedule. Every change should be connected to a relevant proof of concept test (for example: fractography, aging etc., bending test). The schedule should highlight milestones for achivement of the particular objectives (e.g. porosity, cracks, strength, oxidation resistance).

Task 4 : Quality Assurance Concept

- Definition of quality assurance methods (destructive and non destructive).
- Proof of quality assurance concept at hand of component segment and test coupons.

Task 5: Manufacture of component segment and Test Coupons

- Manufacture of test specimen.
- Non Destructive Testing (NDT)
- Destructive investigation for porosity, micro cracks etc.

(prox. 50 parts including).

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

- Experience with high temperature CMC composites.
- Capability to involve a certified material test institute for specimen tests.
- Capability of specimen manufacture.
- Capability of machining CMC. A certifiable quality management system (e.g. ISO9001).
- The partner should highlight the industrial capacity to further develop, optimise, certify and produce the coating under commercial conditions.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Detailed Project Plan	schedule with milestones, technical specification of process and equipment	T0 + 1M
D2	Development of coatings for aero engine applications	Test and development of coating application process	T0 + 6M
D3	Evaluation of material data at elevated temperature (293K, 723K, 1000 K, 1123K) for aged material (hot gas aged material 1000 K/1000h, 1123 K/500 h)	stress tests with aged and unaged material	T0 + 12M
D4	Quality assurance concept	Report on quality assurance concept	T0 + 11M
D5	Deliver of component segment with NDT test and tolerances according to drawing	Finished parts with quality approval for rig /engine tests	T0 + 20M
D6	Method of Manufacturing (MOM)	Generate reliable strength and durability data	T0 + 24M

4. Topic value (€)

1,000,000 Euro
(One Million 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.

5. Remarks

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-2013-01-SAGE-04-23	Development of a high flexible, low cost single crystal casting production process	**Start date**	*T0*
		End date	*T0 + 36M*

1. Topic Description

A first generation of geared turbofan engine (GTF) technology has found its way into the regional and narrow body market due to significant reductions in fuel consumption and noise compared to conventional turbo fan engines.

The purpose of the advanced geared turbofan demonstrator as part of the Sustainable and Green Engine (SAGE) platform is to further advance these technologies and to achieve a next step change in fuel burn reduction combined with an additional decrease in noise emission. Components and modules with new technologies are to be developed, implemented and validated through rig testing as required before integration into a donor engine and SAGE4 full engine demonstration. The successful validation of technologies for this aircraft engine concept will then facilitate the early introduction of innovative new products into the market, and significantly reduce the environmental impact of air transport.

In order to answer the needs of the SAGE4 geared turbofan in terms of research, technological development and demonstration activities, it is planned to offer individual tasks to the industry, universities or any legal entity. Therefore, the present Call for Proposal supports the further development of materials and production processes with a high optimization potential to allow alternate designs of environment-friendly aero-engine components.

Since decades nickel base superalloys play a major role within the material selection of aero engines. Especially the single crystalline and directionally solidified turbine blades and vanes allow very high combustion temperatures which strongly improve the engine efficiency.

Due to complex production processes beginning from melting a master heat and ending up with vacuum heat treatment as well as quality inspection the design and alloy flexibility is very limited.

Simultaneously engine manufactures steadily improve their development cycles by increasing virtual design methods to stay competitive. To bring new ideas into service small part numbers or alloy quantities have to be manufactured for demonstrator and test engines. This is constricted by previous mentioned production chain.

Therefore the objective of the call is the development of a highly flexible production chain for single crystal and directionally solidified blades and vanes made of nickel base superalloys capable to produce even low piece numbers with varying compositions, geometry and casting parameters.

Based on the given requirements, the partners work includes the following tasks:

<u>Task 1: Management</u>

Organisation:

- The partner shall nominate a team dedicated to the project and should inform the topic manager about the name/names of this key staff. At least the responsibility of the following functions shall be clearly addressed: Program (single point contact with the topic manager), Techniques & Quality.

Time Schedule & Work package Description:

- The partner is working 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:

- Quarterly progress reports in writing shall be provided by the partner, referring to all agreed work packages, technical achievement, time schedule, potential risks and proposal for risk mitigation.
- Regular coordination meetings shall be installed (preferred as telecon).
- The partner shall support reporting and agreed review meetings with reasonable visibility on its activities and an adequate level of information.
- The review meetings shall be held in the topic manager´s facility.

General Requirements:

- The partner shall work to a certified standard process.

Task 2: Feasibility study

Task 2 focuses on studying and testing improvement possibilities for all steps of the process chain. Ideas can be proposed into direction of increased cost effectiveness as well as decreased handling times. Both would allow to change geometry and improve compositions more often in response to increase flexibility. Examples could be:

- capability to produce small heat below 500 kg
- fast tooling of wax and ceramic core, e.g. by milling or additive manufacturing
- accelerated mold fabrication
- analytical/ simulative process parameter adaption
- innovative quality control system, e.g. computer tomography

The study include a risk management plan for the improvement packages and must be incorporated in the description of work package.

Task 3: Integration of improvements into process chain

The improved production process should be demonstrated for a small heat on specimens with simplified geometry. The topic manager will define a commercially used alloy specification, e.g. LEK94 a second generation superalloy. Evaluation is supported by microstructure investigations and mechanical characterization of test specimen out of the simplified geometry.

Task 4 : Demo Blade

The whole production process has to be demonstrated for a topic manager given blade design. At this point a full quality control in terms of aero engine component requirements is also expected.

Task 5: Detailed plan for serial implementation

The applicant is asked to show a kind of business concept for serial implementation of developed improvements. This includes a final technical evaluation of all ideas together with an outlook on further steps. A cost analysis for the demo geometry of task 4 allows an economic evaluation.

Add-on

Integration of process simulation/ analytical methods to decrease experimental test loops.

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

Pre-existing technical equipment and/ or supply chain for manufacturing gas turbine blades or vanes made of nickel base superalloys with high gamma prime fraction.

Profound knowledge of technical requirements in terms of gas turbine components (e.g. strength, surface and microstructure quality, specifications, process control, quality requirements).

A certifiable quality management system (e.g. ISO9001).

The partner should highlight the industrial capacity to further develop, optimise, certify and produce parts under commercial conditions.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Detailed Project Plan	schedule with milestones, technical specification of process and equipment	T0 + 1M
D2	Improvement concept	Catalog with improvement ideas in relation to task 2 and first test results	T0+6M
D3	Feasibility study	Demonstration of improvement package on respectively suitable geometries or problems	T0+18M
D4	Improvement integration	Maximum processing time for a topic manager´s certified standard alloy and simplified geometry of 4 month. Evaluation by means of lead time and a comparison of expected mechanical properties to achieved.	T0+22M
D5	Demo Blade	Demonstrating the successful production of a topic manager given blade design for a new alloy within 10 month.	T0+32M
D6	Final report	Final summary about technical and economical results including the analysis of task 5.	T0+36M

4. Topic value (€)

1,500,000 Euro
(One Million and Five Hundred 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.

5. Remarks

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.

Clean Sky Joint Undertaking
SP1-JTI-CS-2013-01-SAGE-04-024

Topic Description

CfP topic number	Title		
JTI-CS-2013-1-SAGE-04-024	Full Scale GTF FDGS Test	**Start date**	*01/09/2013*
		End date	*30/04/2015*

1. Topic Description

Background

The **Geared Turbofan (GTF)** is a promising innovative architecture for the aeronautical market due to significant reduction opportunities in fuel consumption compared to conventional engine architectures.

The Ultra High Bypass Technology has the potential for significant reductions in fuel burn, noise and emissions, and the GTF architecture can enable these benefits while allowing a reasonable engine and core size.

The GTF architecture introduces a decoupling between the turbomachine speed (power turbine) and the propellers speeds enabling separate optimization of both systems, with overall efficiency gain of the whole engine, through the use of a Power reduction Gearbox (PGB), also named **Fan Drive Gear System (FDGS),** being the transmission placed between the Fan and the Low Pressure Turbine.

The FDGS is the heart of the difference between GTF architecture and a conventional one, representing a new engine core module.

Topic Manager is responsible of SAGE4 WP4.2.1 developing a next generation FDGS that will be tested on the ground demonstrator to validate envisaged performance leap.

This Call for Proposal (CfP) integrates the present SAGE4 FDGS innovation activities by performing a demonstration on a full scale power rig of the technologies developed by the CfP manager within the Clean Sky frame, in order to maturate them to TRL 5.

The contents of the CfP are therefore:

- Integrate Topic Manager's rig system design by performing detail design and relevant analyses
- Procure rig components / modules apart from test article and perform final assembly
- Perform power rig FDGS testing

Reference Rig Architecture

To enable detailed preparation of proposal, CfP Applicant shall consider the following baseline rig configuration:

- Mechanical power recirculation. Test Article design point power: about 15 MW
- Identical test article and slave gearbox design (both gearboxes will be provided by Topic Manager)
- modular assembly (Test Article, Slave Gearbox, Torque Application, other rig parts) on dedicated frame; special care shall be taken into account for easy assembly & disassembly procedure of the test Rig and fast installability.
- Torque Application System: around 60.000 N*m
- No feature for misalignment (rotation, parallel offset of input/output shafts) is required.

Gearbox mounted instrumentation (e.g. strain gauges) and relevant conditioning will be provided by Topic Manager.

Rig mounted instrumentation and relevant conditioning, including rotating signal extraction by slip ring(s), are part of this CfP. Applicant should propose a list of instrumentation for control and monitoring including microphones, accelerometers and torquemeter(s).

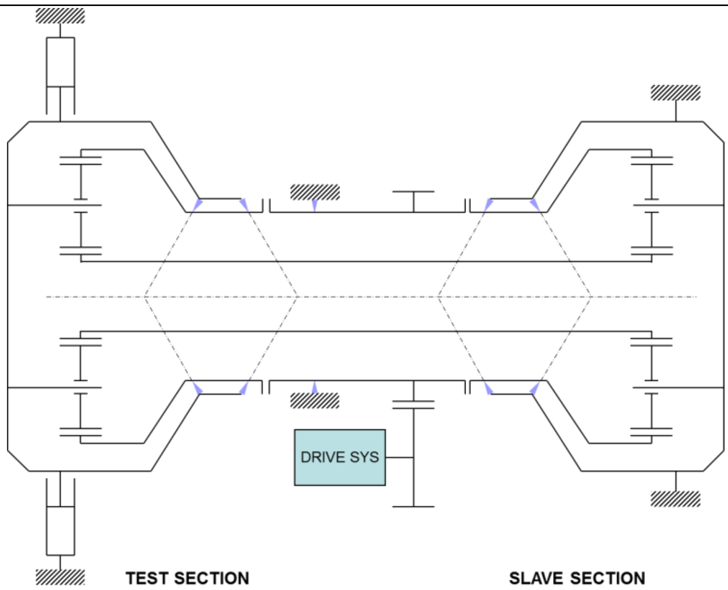


Figure 1: baseline rig configuration, wireframe.

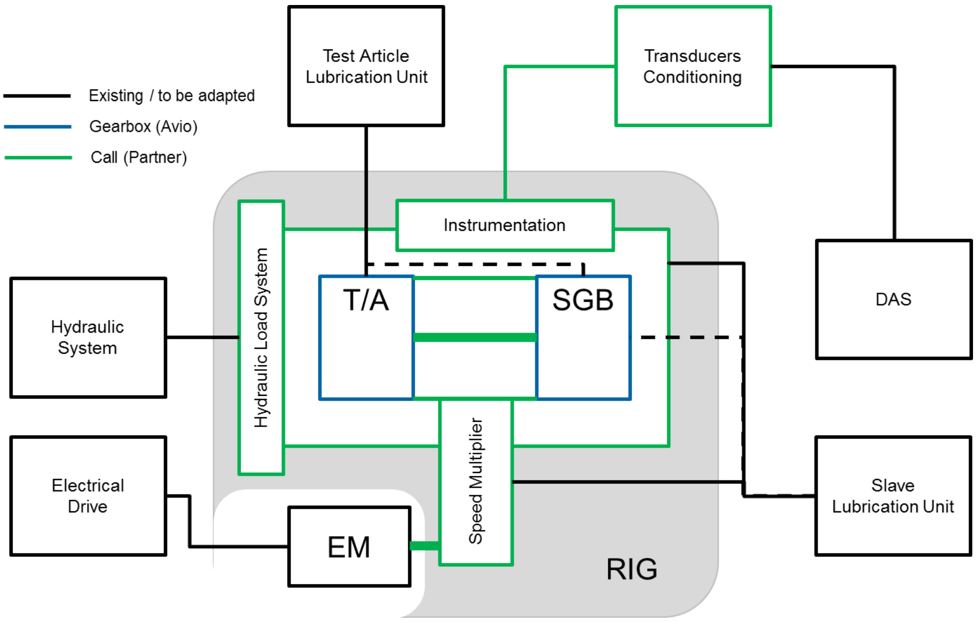


Figure 2: rig, integration into test cell.

Scope of Work

The partners work includes the following Work Packages (WP).

WP1: FDGS Rig Design

Rig overall system design remains of Topic Manager Responsibility.

WP1 includes preliminary and detail design phases of the Power Rig. The Concept Design will be run by the CfP Manager before the CfP launch.

These design phases will be supported by the CfP Manager and the progress will be checked and controlled through a robust Phase & Gate methodology. A Preliminary Design Review and a Critical Design Review are the main identified milestones.

The CfP Manager is in charge of the system design and will present to the applicant the proposed Rig configuration and specification during the kick-off of the CfP project.

The design process is divided into the following main phases:

o Concept Design (carried out in advance of present CfP): trade off analysis and identification of rig reference architecture, system level verifications (e.g. whole system dynamic), finalization of rig specification.

o Preliminary Design: definition of key characteristics that enable compliance to specification, relevant supporting analyses of systems and components. The Preliminary Design phase has a final gate, under the review of the CfP Manager, allowing launching the detail design and raw material procurement.

o Detail Design: detail drawing preparation and verification analyses. The Detail Design phase has a final gate, under the review of the CfP Manager, allowing to close the whole design phase and to finalize parts machining.

The Rig Design task includes the following main deliverables:

- Supporting analyses including FMEA, maintainability, installability and safety requirement analysis
- detail drawings including assembly and disassembly tools
- Assembly and disassembly complete schemes
- Usage and maintenance manual

WP2: FDGS Rig Procurement

This work package is constituted by two main phases: manufacturing and assembly.

Rig manufacturing:

- Long Lead Time Items identification for an early involvement of the potential supplier
- Raw Materials procurement
- Rig component manufacturing and procurement (including instrumentation)
- Assembly equipment procurement

o Rig assembly including integration of gearboxes and instrumentation.

This phase will validate relevant tools and procedures.

Once the Rig has been successfully assembled it has to be transferred in the test facility. Transportation may require partial disassembly depending on logistic.

The Cfp Applicant is in charge of the test facility; the proposed location to be detailed in the Applicant answer to the CfP in order to be assessed by the CfP Manager during the evaluation process. The CfP Manager will propose a back-up solution if needed.

WP3: FDGS Rig Commissioning

This WP covers initial test bed activities:

- rig integration with test facility plant and systems
- rig commissioning to assure proper functioning and data recording
- Initial rig running in preparation of tests execution.

Test facility adaptation to accommodate designed test rig is also part of this WP.

WP4: FDGS Rig Test

The detailed test plan will be defined by the CfP Manager, in accordance with the CfP applicant in parallel with the Design phase.

At this stage it is envisaged that test will be constituted by two main legs:

- Leg A: a series of functional tests to characterize the performance and behaviour of FDGS
- Leg B: endurance test (150 hr) to verify FDGS durability and therefore support its installation into SAGE4 ground demo engine

Test consumables are in charge of the CfP Applicant.

Topic Manager personnel shall be authorised to participate to the commissioning and rig test phases.

- **WP5: FDGS Rig Post Test**

This WP completes the CfP related activities.

It is including post processing of accrued data (e.g vibration order tracking) to enable engineering validation of tested gearbox.

Rig disassembly to perform a mechanical conditioning of the Test Article is also included.

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

Special Skills:

Strong experience in designing and manufacturing test benches suitable for aeronautic parameters is mandatory.

ISO qualification for the design and manufacturing of industrial test benches is mandatory.

The rig shall be compliant with applicable EU/National regulation.

Proven background in complex test campaign of aeronautical mechanical transmission systems and post test activities is mandatory.

Strong expertise in dynamic analysis of complex systems is required.

Strong project and risk management knowledge is a key factor to insure the respect of the request time schedule.

Capability to translate autonomously high level requirements, given by the CfP manager, into measurable criteria and to propose proactively innovative approach through a robust design methodology is an advantage.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
-	KOM	Kick of Meeting & Rig Concept Design evaluation	T0 (*)
D1	PDR	Preliminary Design Review	T0+4
D2	CDR	Critical Design Review	T0+10
D3	Rig Manufacturing and delivery	Delivery of the complete system (including assembly tools and instrumentation equipments)	T0+12
D4	T/A and SGB procurement	Procurement of the Test and Slave Gearboxes (responsibility of the CfP Manager)	T0+12
D5	Rig assembly and acceptance	Assembly and acceptance of the complete system in the identified site, including T/A and SGB.	T0+14
D6a	Test Bed Adaptation	Completion of modifications to test bed to enable rig installation	T0+14
D6b	Rig commissioning	Commissioning of the complete system	T0+16
D7a	FDGS test: step1	FDGS reliability test (for possible implementation into ground engine test bench)	T0+17
D7b	FDGS test: step2	FDGS endurance test (for possible implementation into flight engine test bed)	T0+18
D8	Final test report	Final test report of both FDGS test 1 and 2	T0+20

(*) Rig Concept Design assumed to be available @ T0

4. Topic value (€)

Topic maximum budget:

€ 3,300,000

Three million and three hundred thousand euro

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

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

5. Remarks

Progress report will be requested to the Applicant every two months.

Technical training from applicant to CfP manager staff is required in order to allow operating and maintaining the test bench autonomously if needed.

The proposed test facility should be close enough to the CfP manager premises, in order to minimize possible logistic issues and economical & schedule loss of efficiency.

Collaboration agreement for future partnership in research and technology development activities is requested to be discussed between CfP manager and applicant, in order to maximise the upturn of the present cooperative project.

At the end of the project, if considered in the mutual interest of the parties, the CfP manager will retain the possibility to take over the rig from the applicant.

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-2013-1-SAGE-06-004	Design methods for low emissions	**Start date**	T0
		End date	T0 + 36 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.

An essential enabler to development of such technology is an accurate and reliable suite of tools for prediction of emissions. Although experiments are bound to play a key role in the development and maturing of a lean burn system, emissions prediction tools should be used to drive designs in the right direction and effectively lead to optimal solutions, to be then verified by testing. Unavailability of such a predictive capability would imply a significant increase in the cost and risk of development and maturation of the technology, with the likelihood of producing a sub-optimal design. Today's capabilities are still inadequate to produce accurate and reliable predictions in direct support of lean burn system design, especially due to the inherent challenges in the modelling of the Lean Direct Injection solutions being considered (unsteady aerodynamics and mixing, very complex injector geometries, thermoacoustics, impact of sprays, combustion efficiency issues, etc).

A suite of effective predictive tools exists for supporting the design of conventional rich burn systems.This project aims to develop and improve computational methods that can be used in the design process of low emission combustors. Here the focus is on all combustion emissions, namely NOx, CO, UHC and soot, as different species are limiting the operation of the combustor at different conditions. Refinement of these predictive techniques will go through a process based on improvements of the physics fundamentals followed by validation on combustor demostrator geometries.

Although for lean combustors soot emissions at full power are very low, soot is being formed at rich pilot conditions. Staging is required for lean combustion systems, otherwise the combustion process would extinguish due to too lean mixtures. Predicting soot emissions is very difficult, since the chemical path from intermediate soot precursors to soot particles is long and complicated. Furthermore, for industrial applications affordable models are required, with CFD turn around times of a few days. This implies that the detailed reaction mechanisms have to be reduced. To increase the efficiency of gas turbines, thereby reducing $CO2$ emissions, combustor entry and combustor exit temperatures are increasing. At very high combustor exit conditions, dissociation effect play a role. It is not clear what is happening with the dissociated species in the turbine. These problems will be investigated in this research programme, as well as the impact of the high levels of swirl usually generated by lean burn combustors on the turbine's performance. The goal of this proposal is to develop CFD based methods to support the design of efficient low emission combustors, in order to meet the required emissions targets.

Advanced method will be developed in cooperation with a number of universities. The objectives are:

- Development of a computationally affordable emission model, which can be used in the design process of low emission combustors, to model NOx, CO, UHC and soot emissions. The model will be based on detailed chemistry, but reduction of the chemistry will be attempted. A tabulated chemistry approach will be assessed as well, with a view to choosing the most appropriate method for prediction of combustor emissions.

- Development of advanced spray models. A range of spray models are required in order to improve accuracy of the predictive techniques. In particular, the break-up process of kerosene in airblast fuel injectors has to be captured in phenomenologically based methods due to their computational affordability.

Task 1: Management

Organisation:

– The various 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 be working 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 proposals 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 their activities and an adequate level of information.

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

Task 2: Development of detailed chemical reaction schemes for emissions modelling

Assessment and further development of existing detailed chemistry mechanisms in order to predict NOx, CO and soot emissions in aero gas turbine combustors will be carried out.

The chemistry model should include kerosene, PAH, soot and NOx chemistry and should be able to model soot particle size distribution and high temperature, high pressure conditions.

Task 3: Chemistry reduction

The detailed chemistry models, including the soot chemistry, have to be reduced so that they can be used for CFD computations. Comparisons between detailed and reduced models will be made.

The objective is to model emissions of NOx, CO, UHC and soot with affordable computational costs.

The preferred option to reduce the cost of using detailed chemistry is based on tabulated chemistry.

Task 4: Spray break-up model development

Development of spray break-up models which can be used in combustion system CFD computations will be pursued in this task. Priority will be given to development of computationally cheap, semi-empirical phenomenological models. Assessment and validation of the simplified model will be done againts experimental data, but also detailed break-up models will be further developed and used for benchmarking (VOF, level set, SPH).

Task 5: Validation based on real aero engine gas turbine combustors

The developed spray break-up and emissions models will be used to model aero engine lean burn gas turbine combustors. Emissions will be compared with existing experimental engine data. The methodologies developed will be applied to model the combustor and first row of nozzle guide vanes. The effect of the combustor exit flow field (swirl, temperature streams) on the performance of the turbine will be assessed. Furthemore, an assessment will be made as to whether or how the chemical composition changes within the NGV at very hot conditions.

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

- Experience in chemical kinetics and reduction techniques
- Experience in spray measurements and modelling techniques
- Experience in combustor aerodynamics
- Experience in turbomachinery aerodynamic performance

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1a, D1b, 1c	Management report	3 reports will be written to summarise the project management of the programme, including deliverables, level of spend and dissemination	T0 + 12 months, T0 + 24 months, T0 + 36 months
D2	Detailed reaction mechanisms	The mechanisms will cover NOx, soot, CO and UHC emissions.	T0 + 12 months
D3	Reduced reaction mechanisms	Reduction will aim to deliver computationally affordable mechanisms	T0 + 24 months
D4	Semi-empirical models	The models will cover different injector types (airblast and jet in crossflow). Benchmarking against high fidelity simulations	T0 + 36 months
D5	Validated method for simulation of combustor-turbine interaction	Methods will cover swirl and dissociation CO	T0 + 36 months

4. Topic value (€)

Topic maximum budget:

€ 1,300,000

One million and three hundred thousand euro

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

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

Clean Sky Joint Undertaking
SP1-JTI-CS-2013-01-SAGE-06-005

Topic Description

CfP topic number	Title		
JTI-CS-2013-1-SAGE-06-005	Design methods for durability and operability of low emissions combustors	**Start date**	T0
		End date	T0 + 36 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 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. On the other hand, the requirements for low NOx call for introduction of significant levels fo premixing in the combustor design, which in turns is bound to bring about thermo-acoustic oscillations. Therefore, both combustor cooling and thermo-acoustics are areas where improvements are needed if an operable and durable lean burn combustion system is to be developed and matured. As far as the above-mentioned lean burn demonstrator is concerned, thermoacoustic problems are a particularly high risk to the engine operability.

This project aims to develop methods for accurate and reliable prediction of combustor metal temperature and thermo-acoustics. Although lean burn design could be carried out with existing tools, which have been mainly developed for rich burn systems, these fall significantly short of the requirements. Availability of an enhanced, lean burn specific set of tools and practices for cooling and thermoacoustic would allow reducing cost and risk in development and maturation of this technology significantly. As a matter of fact, the current state of the art is based on going up to the expensive TRL5 testing before some dependable understanding can be obtained about thermo-acoustic and thermal behaviour of the combustor.

Design of low emissions combustors is based on a trade off between cooling and aerothermal performance, as low emissions can be achieved only if cooling flows are minimised. However, combustor life targets are becoming ever more stringent. A comprehensive set of tools will be developed and delivered for the prediction of combustor metal temperature. The required tools and practices will have to range from CFD methods that can be readily used in support of preliminary design to techniques accounting for the unsteady interaction between combustion and cooling flows. Both convection and radiation will be investigated. Different cooling styles will be considered and the corresponding modelling issues addressed. Attention will also be paid to the integration of different tools that is required to speed up the combustor thermal analysis process.

Although low NOx combustor designs based on Lean Direct Injection concepts have been already demonstrated up to high TRL, their operability can be jeopardised by thermo-acoustic oscillations, which can endanger the engine's integrity. So, together with durability, thermoacoustics-related operability issues will be investigated as part of this programme. A suite of validated modelling tools will be developed and delivered, which will account for important effects that are known to have an impact on the combustor thermoacoustic behaviour.

A holistic approach will be adopted for investigation of combustor thermoacoustics. Both the overall system and the fuel injector behaviours will be investigated. In particular, emphasis will be put in the development and validation of methods able to assess the acoustic response of an injector aerodynamics and spray distribution to acoustic perturbation, with a view to developing a predictive capability leading to robust designs. Forced and self-sustained flame behaviours will be modelled. The investigations will cover both high and low frequency thermo-acoustic instabilities. Emphasis will be put on the validation of high frequency rumble phenomena, based on data coming from an available, low TRL annular rig equipped with advanced diagnostics.

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: Development of methods for modelling of impingement-effusion tiles

Impingement-effusion tiles offer a robust design solution for minimisation of the cooling budget for low emissions combustors. A desireable feature of this cooling system is the flexibility that can be achieved by tailoring the effusion flow to target hot spots. A capability to model these effects in a quantitatively accurate way will be developed as part of this task. The wide range of lengthscales that should be resolved by CFD models attempting to simulate effusion geometries make this explicit approach impractical. The approach proposed in this task will be based on derivation of correlations to be embedded in a simple, low resolution CFD model via sub-grid-scale models. The data used for derivation of such correlations will come from a mixture of experimental and high fidelity CFD. The models derived will allow calculation of metal temperature at a relatively early stage of the design process.

As part of this task, LES methods will be used to characterise the unsteady nature of the interaction between the effusion cooling film and the mainstream injector-generated flow.

Task 3: Development of methods for pedestal tiles

Pedestal tiles are a highly effective way of protecting the liner from the hot combustion gases. Even for pedestal tiles, sub-models will be derived that will be implemented in a RANS model to account for aerodynamic and heat transfer effects without the need to resolve the very small geometric features. LES will be used to characterise the unsteady nature of the hot side cooling of pedestal tiles.

Task 4: validation of radiation models

Radiation is a significant source of heat load on combustor liners, whose prediction is at the same time important and uncertain. As radiation is a strong function of the combustor soot distribution, different soot models will be used as a basis for the prediction of the radiative load. Furthermore, sensitivity studies will be performed to the impact on the calculated radiation load due to the use of different radiation models. This task will deliver a validated, computationally affordable radiation model for both lean and rich burn systems.

Task 5: Development of a smart system for thermal analysis of combustors

Even if conjugate heat transfer CFD is bound to play an ever increasing role in cooling design and life assessments, Finite Element (FE) approaches still offer a pragmatic route to calculate combustor metal temperatures. This task will deliver integration of the various tools currently used in the thermal analysis of a combustor, such as a flow network solver for the cold side, a CFD solver for the hot side, a FE solver for the conduction calculation together with a master geometry model. The resulting capabilities will enact a significant speed up of the analysis process, thereby paving the way to the pursuit of a statistical approach to the calculation of combustor metal temperatures.

Task 6: fuel injector response to acoustic oscillations

Pressure fluctuations induced by thermo-acoustic coupling force the injector, which responds with amplitudes and frequencies that are injector specific. Objective of this task will be the development and validation of modelling techniques to assess the response of injectors to representative pressure fluctuations. Modelling approaches will be developed and validated to simulate the impact of pressure fluctuations on the spray response as well, which can play an important role in itself.

Task 7: Development and validation of CFD methods for prediction of high frequency thermoacoustic against full annular rig

The limited measurement suite usually available in full annular rigs makes it particularly hard to reach a good understanding of high frequency rumble. An approach often pursued in order to characterise the response of a flame to pressure oscillations is to force it in a single sector rig, usually with axial perturbations. However, high frequency thermoacoustic oscillations occurring in aero-engine combustors are mostly showing azimuthal modes. In actual fact, there is significant uncertainty about the acceptability of this read across from single sector to full annular results for annular combustors. A low TRL full annular rig, which has been developed recently, will be used as a validation platform for the CFD methods which will be developed in this task. In particular, full annular simulations will be attempted, as well as methods for derivation of flame transfer functions from a single sector model.

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

- Experience in experimental techniques for characterisation of cooling systems
- Experience in cooling modelling methods
- Experience in sub-grid-scale modelling
- Experience in Large Eddy Simulation approaches
- Experience in experimental and numerical methods for thermoacoustics, ranging from low order to full blown 3D methods
- Experience in design and analysis methods for aero-engine combustors

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1a, D1b, 1c	Management report	3 reports will be written to summarise the project management of the programme, including deliverables, level of spend and dissemination	T0 + 12 months, T0 + 24 months, T0 + 36 months
D2	Model for impingement effusion	Validated method for simulation of the hot side aerodynamics and heat transfer of an effusion arrangement. Validated sub-grid-scale model for impingement-effusion arrangements, inclusive of the cold side	T0 + 36 months
D3	Sub-model for pedestal tiles	Validated sub-grid scale model for pedestal tiles and heatshields	T0 + 12 months
D4	Radiation model	Validated methodology and model for accurate prediction of radiative load based on computationally affordable soot model	T0 + 36 months
D5	Smart system for combustor thermals	Integrated system encompassing geometry, airflow, CFD and thermal modelling for aero—engine combustors	T0 + 36 months
D6	Method for modelling the response of injector to acoustic forcing	The method will include both the single and two-phase response	T0 + 36 months
D7	Validated CFD method for simulation of annular rig instabilities	The method will include a comparison between single sector and full annular modelling, based on validation	T0 + 36 months

4. Topic value (€)

Topic maximum budget:

€ 850,000

Eight hundred and fifty thousand euro

The proposed topic value is a maximum gross value for the proposed activity.
Please note that VAT is not applicable in the frame of the Clean Sky program.

Clean Sky Joint Undertaking
SP1-JTI-CS-2013-01-SAGE-06-006

Topic Description

CfP topic number	Title		
JTI-CS-2013-1-SAGE-06-006	Advanced materials for lean burn combustion system components using Laser- Additive Layer Manufacturing (L-ALM)	**Start date**	T0
		End date	T0 + 18months

1. Topic Description

SAGE6 project aims at development and demonstration of a Lean Burn Combustion System in support of the ACARE 2020 goals and Flightpath 2050. RTD activities are required to develop economic manufacturing methods for the novel combustion components, foreseen as required for realisation of lean burn engines.

Using European 'best-of breed' laser- Additive Layer Manufacturing (L-ALM) equipment, the objective of the work package is to develop process parameters, necessary machine settings and heat treatments to produce nickel superalloy material from L-ALM suitable for high temperature applications to Technology Readiness Level (TRL) 6- "technology demonstrator- prototype demonstration in a relevent environment".

Laser Additive Layer Manufacturing of combustion components is being demonstrated at TRL4, and demonstrated the technical capable of forming the required complex geometries. The supply of rig and engine test components in 'easy to weld'- alloys has become commonplace. There remains however the need to process the most advanced ('unweldable') nickel superalloys (with high levels of gamma-prime hardening elements) in the geometries of lean burn combustion components.

C1023, CM247LC and similar advanced alloys have be L-ALM processed and a good microstructure reported after post processing, however mechanical properties are as-yet unknown for fully heat treated material. The capability to produce the desired geometries in these advanced materials remains undemonstrated to Technology Readiness Level (TRL) 6- "technology demonstrator-prototype demonstration in a relevent environment".

A leading supplier of nickel superalloy components for combustion parts is required.

The Partner shall in particular perform the following tasks:

Task 1- Management

Organisation:

The Partner shall nominate a team dedicated to the project and inform Rolls-Royce project manager about the name/names of this key staff. There shall be a project manager who is the single point contact with Rolls-Royce.

Time Schedule & Work-package Description:

The Partner shall work to an agreed time-schedule & work-package description, being that laid out here, further detailed as required and agreed with Rolls-Royce at the beginning of the project.

Progress Reporting & Reviews:

Quarterly progress reports in writing shall be provided by the partner, referring to all agreed work packages, technical achievements, time schedules, potential risks and proposals for risk mitigation.

Regular coordination meetings shall be conducted via telecom or at locations of Rolls-Royce choosing with the Partner providing reasonable visibility on its activities and an adequate level of information.

The activities will be managed with a Phase & Gate approach. Rolls-Royce will approve gates and authorise progress to subsequent phases.

The Partner shall submit a final report to Rolls-Royce (Task 6) summarising the achievements, futher requirements (if any) and articulating a route to commercial access thereby enabling widespread manufacturing using of the capabilities developed here

Task 2 Reporting on the State of the Art and recommendations

The Partner shall study the relevent literature and report to Rolls-Royce on the state of the art and its own capabilities. The Partner will recommend new and novel process methodologies for L-ALM processing and heat treating a suitable candidate nickel superalloy of interest.

Task 3 Scoping of process development experiments

Materials will be down-selected from the candidate materials based on performance and ease of processing. A materials development program will be documented by the Partner and agreed with Rolls-Royce including a representative combustion component geometry with defined accuracy and surface finish requirements.

A procurement plan for the variance trials of the developed process shall be agreed upon for the necessasary materials and resource access to enable variance trials to be performed in a timely manner.

This development will address the mechanical properties required for the combustion component applications (typically equivalent to cast) in the down selected material.

Task 4 Materials development experimentation

The partner shall dilligently execute the materials development program agreed at Task 3, reporting regularly to Rolls Royce. Analysis of the materials data generated will be carried out by the Partner.

Processes yielding adequate mechanical properties will be tested to ensure that they are also suitable for building the representative combustion component geometry (crack-free) to the accuracy and surface finish requirements agreed in Task 2.

If problems persist an alternative material or geometry may be selected.

This task completes once a process capable of building the selected material, the selected geometry and achieving the required mechanical properties has been demonstrated.

Task 5 Variance trials

The Partner shall take the process output from Task 4 and test for stability and repeatability to TRL-level 6. Tests will be performed within batch (across the build plate), through powder recycling/reuse and across machines.

Task 6 Reporting, cost modelling and recommendations

The Partner shall prepare a report for Rolls-Royce on the materials development and include a cost model for early stage production and recommendations for both materials improvements and cost reduction.

This report shall summarise the achievements, futher requirements (if any) and articulate a route to commercial access thereby enabling widespread manufacturing using of the capabilities developed here.

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

Suitably qualified experts in L-ALM of nickel alloys and extensive experience in process development, process validation and manufacture of nickel superalloy aeroengine parts.

Experience in managing R&T and R&D programs in cooperation with Rolls Royce; in particular experience of working with and reporting to Rolls-Royce materials experts.

The relevent environment to perform the development work and demonstrate the deliverables. This should include the necessary best of breed L-ALM equipment and supporting anciliary equipment and facilities to develop processes and operate at TRL level 6.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Representative geometry built in selected material with a process yielding acceptable mechanical properties	Completion of materials development in this program	T+12 months
D2	Final reporting- mechanical properties, accuracy and surface finish of representative design, cost model, recommendations for improvements and plan for commercial access at higher TRL		T+18 months

4. Topic value (€)

Topic maximum budget:

€ 1,000,000

One million euro

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

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

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 feature selection process.

d) The proposal must include details of supplier agreements and dependencies on sub-systems and access to IP held by third parties.

e) The proposal should clearly describe the methods by which the Partner will demonstrate technical equivalence to best of breed L-ALM methods and demonstrate productivity improvements.

Clean Sky – Smart Fixed Wing Aircraft

Identification	ITD - AREA - TOPIC	topics	VALUE (€)	MAX FUND (€)
JTI-CS-SFWA	**Clean Sky - Smart Fixed Wing Aircraft**	**2**	**3,000,000**	**2,250,000**
JTI-CS-SFWA-01	*Area01 – Smart Wing Technology*			
JTI-CS-SFWA-02	*Area02 - New Configuration*		**3,000,000**	
JTI-CS-2013-01-SFWA-02-038	Design and manufacturing of a representative new generation business jet model for high and low speed tests		2,000,000	
JTI-CS-2013-01-SFWA-02-041	Blade trajectory testing		1,000,000	
JTI-CS-SFWA-03	*Area03 – Flight Demonstrators*			

Topic Description

CfP Topic Number	Title		
JTI-CS-2013-01-SFWA-02-038	Design and manufacturing of a business jet model for high and low speed tests	**Start Date**	10-2013
		End Date	12-2014

1. Topic Description

This topic is devoted to the model design and manufacture of a representative next generation high speed fuel efficient business jet. This model will be highly instrumented and will present a high level of modularity to enable the balance of the benefits of each integrated technology at aircraft level. The model will be tested at high speed in an atmospheric tunnel and at low speed in a pressurized tunnel.

Dimensions and loads

A full model is required to enable handling quality tests of the innovative stabilizing solution. The model will be around 3m span for 3m length for a wing area of 1.25m².

Two sets of wings will be tested on the model:

a. one highly instrumented with steady and unsteady pressure transducers for buffet onset and drag issues,
b. one highly modular with all the needed movable parts (slats, flaps, spoilers, ailerons …).

Wing "b." must be capable of both high and low speed testing. On a first assumption, loads are almost the same in both cases (high speed atmospheric vs. low speed pressurized). Loads to be considered are therefore:

- -15kN < Fz < 45kN
- -4kN < Fx < 9kN
- -8.5kNm < My < 6.5kNm

Model parts

The different tests require the following model hardware:

- One front and one central fuselage. The balance will be provided by the Wind tunnel operator and will be fitted inside of the central fuselage. For the air intake tests, a dummy balance will be installed inside of the model.
- Two sets of wings with their body-fairing. Both wings will be fixed to the fuselage using an interface plate that enables a future re-use of the model with a different wing root:
    - One "clean" wing allowing a limited number of movable parts on the trailing edge. The applicant shall integrate in its cost estimation trailing edge modularity for camber effect (3 different trailing edges divided in 3 parts in span on each wing (port/starboard) i.e. a maximum of 18 different parts between 70% and 100% chord). A removable wingtip and a winglet are required on each wing.
        - One wing with all movable parts needed for low and high speed tests (slats, flaps, spoilers …). On this wing, it is asked for:

        - A set of slotted-slats with limited X & Z setting capacity (gap & overlap)
        - Two sets of flap architectures (including for each: flap, flap roof, spoiler, Air brake…).
            - Each flap will be capable of at least 5 different deflection angles (including positive, null and negative angles) & for each angle a (x,z) setting capacity.
            - Each flap architecture will include a set of spoilers or airbrakes with at least 2 negative deflection angles together with a positive deflection capacity.
        - An aileron capable of -35° to 35° deflection
        - A removable wingtip and a winglet.

- Different mounting capacities of the model for high and low speed tests. The possible mountings are:
  - Ventral strut
  - Z-sting
  - Rear sting
- The aft-fuselage is representative of an innovative trimming configuration with:
  - All movable Canard – a solution of motorization has to be proposed by the applicant.
  - All movable V-Tail. Two different V-Tails are to be taken into account for cost estimates. A solution of motorization has to be proposed by the applicant for at least one of the two V-Tails.
  - A set of three through flow nacelles.
- A dedicated nacelle to be fitted with an instrumented rake located in the compressor entry plane. This nacelle will be used in both central and lateral position. An aspirating device that enables to simulate the real engine mass-flow rate will be fixed at the trailing edge of this nacelle. The applicant shall design and manufacture the interface part between the nacelle and the tube provided by the Wind-tunnel operator. Differently sized interchangeable pylons shall be designed and manufactured for parametric studies. The cost estimates shall take into account 3 pylons for central and 3 more for lateral nacelle locations.
- A single set of landing gears with its opening doors and cavity

Model Instrumentation

The model will be instrumented with:

- A removable instrumented rake (with 40 pressure transducers classically installed in 8 legs with 5 probes per leg) fitted in a dedicated nacelle for air intake distortion study at low and high speed. The applicant shall propose a way to design and manufacture the rake to be compatible with different compressor entry plane diameters. As total pressure is very different between low and high speed tests, one shall take into account that two sets of pressure transducers may be needed (one for each test). The cost estimation may be done considering purchasing of differential XCQ-062 5 psi for high speed tests and XCQ-062 25 psi for low speed ones. Ahead of the rake, a first set-up of 8 static pressure probes is required. One shall also consider that some pressure probes (roughly 20) will be needed at the skin of the air intake at different sections.
- Wing a) will be instrumented with steady and unsteady pressure transducers with quick connectors (a total of 50 unsteady transducers and 100 steady pressure ports on the model). Some of them are in interchangeable trailing edge parts. For cost estimation, one shall consider the purchase of LL-072 A Kulite pellicular absolute pressure transducers (peak pressure to be defined later but in the range of 1 bar).
- Wing b) will be equipped with roughly 250 steady pressure ports (some in movable parts). Strain gauges and/or balance(s) or any innovative load estimation system for movable elements (flap, aileron) is to be fitted in the wing.
- Strain gauges and/or balance(s) or any innovative load estimation system will be integrated in the model to study loads from:
  - HTP and its movable elements
  - Canard
- Two line of steady pressure ports will be integrated on the Canard (50 maximum on the whole part)
- Two line of steady pressure ports will be integrated on one V-Tail (50 maximum on the whole part)
- A way to measure laminar extension on different subparts of the model will be integrated depending on wind tunnel operator recommendation (IR layer expected). Insulation material (Vespel for example) may therefore be needed on a limited area (1m span x 0.5m chord wise x 0.35m width).

Shape tolerances

The applicant shall be compliant with the following tolerances:

Shape deviation: ±0,1 mm
Deflection deviation for all movable elements (including slats and flaps): ±0,1°
Trim angle of the HTP: ±0,05°
Overall size of the model: ±0,5 mm
Local twist angle (reference angle at root): ± 0,05°
Wing dihedral: ±0,1°
Angle fitting of the wing: ±0,05°
Flap gap and overlap: ±0,15 mm
Slat gap & overlap: ±0,1 mm
Roughness: Ra < 0,2 µm

No step (either forward or backward facing) shall appear between the different subparts after fitting. Waviness constraint is 0.5% on the first 25% of the wing chord (based on a 5mm length sample).

A geometric control is needed to check these generic tolerances before the final acceptance of the model. Gap and overlap of the high-lift system will be checked under representative loads. The applicant is free to propose innovative system to control the model (optical, etc …).

General Remarks

The applicant shall propose innovative ways to manipulate and to integrate the instrumentation in order to accurately measure the loads on the different subparts of the model with the aim of optimizing the wind tunnel productivity. Tests will be done under heavy loads that make this kind of tests very challenging (safety of the model vs accuracy of the measurement).
The applicant is free to propose features to save wind tunnel occupancy and increase the level and quality of results of the tests. Individual solutions for the motorization of sub parts shall be studied and proposed by the applicant.
If needed, the applicant shall show the maturity of its design and innovative solutions by limited demonstrations (mock-up, loads validation ...).
The applicant shall also propose solutions for the rake design and manufacture so as to be capable of different compressor entry plane diameters.
The applicant shall issue a complete stress report as required by the wind tunnel operator.
The applicant is responsible of the shipment of the model to the first wind tunnel facility. The model and its parts have to be delivered in robust box(es) for transport and storage during tests.

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

- The applicant shall demonstrate a large experience of model design & manufacture for high speed and pressurized tests. The loads (Pi up to 4 bars) on the model ask for demanding machining and fitting processes.
- The geometries will be provided using CATIA V5 R18 or R20 software. The applicant shall therefore have compatible software capacity to read input data as provided by the CfP topic manager and to exchange with him at each stage of the project data for progress reviews.
- The applicant shall be capable of providing the required high level of surface tolerances and fitting quality of the model. This includes the capacity to perform the needed geometrical control of the shapes of the model.

3. Major Deliverables and Schedule

Del. Ref. Nr.	Title	Description (if applicable)	Due
1	Model instrumentation layout	Description of instrumentation integration	M0 + 6M
2	Model design review	Final review of the model before manufacturing	M0 + 6M
3	Model stress report	Stress report of the model	M0 + 8M
4	Model control report	Geometrical control report	M0 + 14M
5	Model delivery		M0 + 14M

4. Topic value

The total value for this work package shall not exceed

2,000,000
[Two million 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
-	-	-	-	500	1500	-

Topic Description

CfP Topic Number	Title		
JTI-CS-2013-01-SFWA-02-041	**Blade Trajectory testing**	**Start Date**	09-2013
		End Date	05-2015

1. Topic Description

General background and purpose of the tests
In the scope of the future certification of a Counter Rotating Open Rotor (CROR) engine powered aircraft, aircraft manufacturer should address and assume the event of engine burst including the release / loss of a fragment of an Open Rotor Blade in order to assess and mitigate the risks for the aircraft.

For the associated risk assessment, several features of Fragment Model of Open Rotor Blade Release (ORBR) are not directly established by regulation and shall be fixed through specific demonstration. This is particularly the case for the fragment trajectory model features for which wind tunnel tests have to be performed by the applicant.
The prime purpose of the blade trajectory tests as specified below is to support the demonstration of an ORBR fragment trajectory model for a predefined CROR engine design. The secondary purpose is to better understand the driving parameters which determine the trajectory path of the blade fragment and finally to validate the numerical tools.

1- Content of the workpackage
The blade trajectory wind tunnel tests have to be performed with a rotating device. The work of the applicant includes:
- Test definition
- Design and manufacturing of all test samples and any test rig component needed for conducting the tests
- Performance of tests
- Data reduction, validation and final data release

2- Purpose of the test
The wind tunnel test shall provide data for the validation of an existing simulation tool for predicting the fragment trajectory. For this purpose the aerodynamic forces representative of the forces which the fragment encounters on its trajectory have to be measured. The validation of the simulation tool is not performed by the applicant.

3- Principle of the test
The test sample(s) representing the fragment will be installed on a rotating device inside a wind tunnel. The release velocity of the fragment at the gravity centre will be replaced by a steady wind tunnel flow. These tests do not include any (free) release of fragment or test sample.

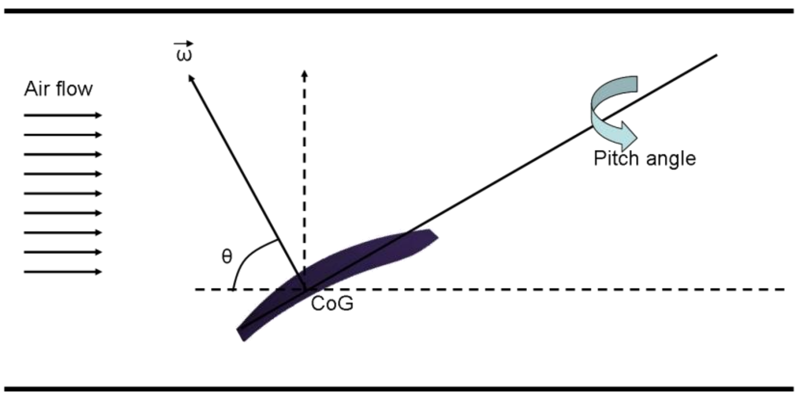


Fig. 1: Description of rotation axis, Windtunnel airflow, □ angle and “pitch” angle

4 -Test articles and installation

The tests should be performed at the highest possible (full) scale. However, a reduction down to 1/4 scale will be accepted, using a similitude on the advance ratio: J = V0 / n x D
(V0 = upstream velocity [m/s], n = Ω/2π rotation frequency [s^{-1}], D = fragment length [m]).

The test articles shall be representative of the aerodynamic shapes of the blade fragments. There is no need for mass and inertia similitude. The shapes will be provided by the task consortium as an input to the applicant.

Two to five different fragment sizes have to be tested which could vary (for the full scale) from 800 mm to 1600 mm.

The fragment pitch angles shall represent engine take-off and cruise settings. The pitch settings need to be adjustable on a range of +/-20° (unless specific samples are manufactured). The pitch angle adjustment is not required to operate during the test itself, although it could be found of interest by the applicant to increase test productivity.

The fragment samples will be installed on a rotating device :
- The test sample rotation axis will be lined up on its gravity centre. The position of the gravity centre will be provided to the applicant,
- The test sample rotation speed shall vary up to 90 rad/s (at full scale and Mach = 0.3 conditions).

The rotating device shall enable incidence and sideslip variation of the rotation plane, to represent the fragment attitudes encountered during its trajectory within the following range:
- Incidence (□ angle as shown on fig.1) range from 0° to about 90°.
- Sideslip angle range from 0° to 30° (lower priority, not a requirement, but beneficial for the study).

The test support manufactured by the applicant shall minimise its aerodynamic perturbation throughout the test envelop. Proper demonstration shall be done by the applicant.

The applicant shall demonstrate the test setup dynamic behaviour such that
- No critical resonances are present within the test range
- Predicted deflexions are compatible with required measurement accuracies

5- Test conditions and test matrix

Test shall be performed at upstream Mach numbers of M0.2 and M0.3.

Reynolds number effects will not really be considered, so that tests could be performed at ambient pressure and temperature (atmospheric wind tunnel).

The test matrix will be supplied to the applicant. It will include
- rotation speed effects
- incidence and sideslip effects
- blade shape and blade pitch effects
- any additional run to validate the results

The following table provides the required number of test campaigns, the minimum and maximum numbers of tested conditions. Typically, a testing condition corresponds to a test run assuming frozen settings of pitch angle, fragment shape, incidence and sideslip angle.

Number of tested conditions			Number of test campaigns
Total	per test campaign		
Min.	Min.	Max.	
85	30	55	2

Table 1 – Summary of number of tested conditions and test campaigns

6- Specification of expected output data and testing measurements system

The following main parameters shall be measured:
- Wind tunnel parameters (Mach, pressure, temperature)
- Model attitudes
- Unsteady forces and momentums applied on the fragments (6 components)

The uncertainty shall ideally be less than 10% of measurement maximum values including measurement, repeatability, wall and support effects. In the proposal evaluation process, the compliance with this target will be a contributing factor to the selection of the proposal.

The measurements in stabilised conditions shall met the following requirements:
- Sampling frequency: less than 1° of test sample rotation angle
- Sampling duration: at least 5 rotations

7 - Required data for the proposal

The proposal shall contain at least the following information

- The exact number of test samples and test conditions
- Preliminary description of the test definition, experimental set-up and initial view on compliance with respect to requirements expressed in the current call for proposal
- Description of adjustment system (pitch angle and rotation axis change)
- Description and uncertainty of the force & momentum measurement system including data correction

Assessment of blade flow representativeness (wind-tunnel airflow homogeneity) and the influence of the blade support.

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

- The applicant should have a sound industrial background in complex testing activities
- The applicant has to demonstrate experience in similar complex wind tunnel experiment
- Appropriate Certificates and ISO standards

3. Major Deliverables and Schedule

Updated deliverable list is subject to negotiation between the applicant and the task consortium at CFP contract award.

Del. Ref. Nr.	Title	Description (if applicable)	Due
1	Progress report	Test preparation progress report including the detailed test specifications for the first campaign of testing	M0 + 3 M
2	Test campaign 1 result presentation	Presentation of test results of campaign 1	M0 + 9 M
3	Test campaign 1 result report	Report of test campaign1 with all data	M0 + 10 M
4	Test campaign 2 result presentation	Presentation of test results of campaign 2	M0 + 15 M
5	Final Test result report	Final Report of all test campaigns	M0 + 20 M

4. Topic value

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

1,000,000 Euro
[One million 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
-	-	-	-	200	600	200

Clean Sky – Systems for Green Operations

Identification	ITD - AREA - TOPIC	topics	VALUE (€)	MAX FUND (€)
JTI-CS-SGO	**Clean Sky - Systems for Green Operations**	**20**	**10,500,000**	**7,875,000**
JTI-CS-SGO-01	*Area-01 - Definition of Aircraft Solutions and explotation strategies*			
JTI-CS-SGO-02	*Area-02 - Management of Aircraft Energy*		**6,250,000**	
JTI-CS-2013-01-SGO-02-051	Ram-air fan optimization for electrical ECS application		600,000	
JTI-CS-2013-01-SGO-02-056	Integrated design tool to support EWIS optimisation		300,000	
JTI-CS-2013-01-SGO-02-057	PWM High Voltage connectors		200,000	
JTI-CS-2013-01-SGO-02-058	Optimized power cable for skin effects		200,000	
JTI-CS-2013-01-SGO-02-061	Technology development and fabrication of integrated solid-state power switches		650,000	
JTI-CS-2013-01-SGO-02-064	Cooperative System Design Simulation Environment for Energy System Applications		250,000	
JTI-CS-2013-01-SGO-02-065	Modelica library of detailed magnetic effects in rotating machinery		250,000	
JTI-CS-2013-01-SGO-02-066	HVDC fuses design, development, validation and integration		400,000	
JTI-CS-2013-01-SGO-02-067	Optimized insulation for adapted characteristics		300,000	
JTI-CS-2013-01-SGO-02-068	Harness integrated sensors network for wiring health monitoring		500,000	
JTI-CS-2013-01-SGO-02-069	High power SiC diodes for Starter-Generator rotating rectifier bridge applications		600,000	
JTI-CS-2013-01-SGO-02-070	New magnetic materials for machines		600,000	
JTI-CS-2013-01-SGO-02-071	Bi-phase cooling system suitable for power electronics dedicated to more electrical aircraft		800,000	
JTI-CS-2013-01-SGO-02-072	Li-Ion battery for optimized DC network power conversion		600,000	
JTI-CS-SGO-03	*Area-03 - Management of Trajectory and Mission*		**2,050,000**	
JTI-CS-2013-01-SGO-03-021	Flight Operations for novel Continuous Descents		500,000	
JTI-CS-2013-01-SGO-03-022	Validation of avionic polarimetric radar X-band meteorological models and algorithms through experimental tests		1,000,000	
JTI-CS-2013-01-SGO-03-023	Simulation of Pilot Behaviour and Clearance Negatiation in Trajectory Changes Management		550,000	
JTI-CS-SGO-04	*Area-04 - Aircraft Demonstrators*		**2,200,000**	
JTI-CS-2013-01-SGO-04-006	Thermal Mock-ups for Thermal Management of a Ground Integration Test Rig		1,200,000	
JTI-CS-2013-01-SGO-04-007	Design and manufacturing of a 10kW AC-DC converter unit		500,000	
JTI-CS-2013-01-SGO-04-008	Electrical equipment modelling for test rig virtual integration		500,000	

Topic Description

CfP topic number	Title		
JTI-CS-2013-01-SGO-02-051	Ram air fan optimization for electrical ECS application	**End date**	December 2014
		Start date	July 2013

1. Background

On an electrical ECS pack, outside air is used to remove heat from the cooled system. The outside air flow is generated on ground thanks to a vacuum device. The present subject deals with electrical fan solution used as vacuum device for ram air flow generation.

The challenge of optimizing such a component for this application is double.

First, from aerodynamic point of view, the fan shall be capable to generate pressure drop whatever the flow without surge issues. Indeed, the ram air fan is used to suck main air flow through ECS pack main heat exchanger for cabin cooling and in the meantime to suck small amount of flow through ECS pack electrical motor stator for cooling. Due to ECS control logics, the fan shall be also capable to ensure ECS motor stator cooling without any flow from main heat exchanger. In this case it shall provide the same pressure rise with a very limited flow.

Then, the fan is installed downstream of the ECS main heat exchanger. Therefore, high temperature air can enter the fan and specific concept shall be implemented for fan integration to enable fan mechanical and electrical subpart cooling.

Finally, technology and solution selected to comply with these last constraints shall minimize impact on performance efficiency and component reliability and availability so as to achieve global ECS objectives.

2. Scope of work

The proposed work package can be separated into three sub-topics:

1) Analysis of aerodynamic issues and elaboration of a solution avoiding fan surge in limited flow conditions

2) Validation of the proposed aerodynamic concept through laboratory test on a prototype

3) Analysis and development of a solution enabling thermal management of the fan in hot air condition.

3. Type of work

The type of work is a function of each sub-topic:

1) Bibliographic search, brainstorming, and predesign of several aerodynamic concepts. Trade off to select the most suitable solution.

2) Detail design of the selected solution, prototype manufacturing and performance testing to validate flow capability and isentropic performances.

3) Bibliographic search, brainstorming and creative work, preliminary technical design of an electrical fan which may involve component integration optimization and thermal analysis so as to withstand high temperature conditions.

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

SME and/or laboratory having a significant experience on::

1) Engineering and knowledge of air fan aerodynamic.

2) CFD modelling and simulation (using Star-CCM+ by CD-adapco or software to be discussed with the Topic Manager).

3) Engineering and demonstrator production experience.

4) Electrical fan integration and thermal modelling experience

5. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1.1	Bibliographic search report on fan antisurge technologies	3 months	T0+ 4 Months
D1.2	High flow range fan technologies description and selection report	9 months	T0+ 6 Months
D2.1	Prototype fan design report	6 months	T0+ 12 Months
D2.2	Prototype fan	6 months	T0+ 16 Months
D2.3	Prototype fan test and performance validation report	3 months	T0+ 18 Months
D3.1	Bibliographic search report on high temperature electrical fan concept	3 months	T0+ 4 Months
D3.2	Preliminary design/sizing of chosen fan thermal management solution	9 months	T0+ 7 Months
D3.3	Detailed design of chosen fan thermal management solution	6 months	T0+ 11 Months

6. Topic value (€)

The **maximum value** for this topic is

600,000 €

[Six Hundred Thousand euro]

Please note any proposal above this value will be NOT be eligible.

7. Remarks

Each of the three sub-topics may be considered as separate work packages, to be attributed to single or different partners.

Following relevance of proposed technical solution and evaluation of its efficiency by the partner, The Topic Manager may eventually test the prototype in a representative environment using an electrical pack.

Topic description

CfP Nbr	Title		
JTI-CS-2013-1-SGO-02-056	Integrated design tool to support EWIS optimisation	**End date**	December 2014
		Start date	July 2013

1. Background

In the present economical context, the reduction of fuel consumption becomes imperative. Thus, the weight of the electrical system has to be diminished by minimising the total mass under constraints.

The sizing of electrical cables' gauges is made nowadays using two physical criteria:

Thermal – translated by a maximum heating value, relative to the normal ambient temperature; the maximum operating temperature that a cable can reach without damage of the insulation or the conductive core is taken into account for sizing circuit breakers (fault functioning);

Electrical - maximum voltage drop on the electrical supply link, taking into account all the cables composing the link in question.

The thermal sizing is made using standards that furnish the dependency between the temperature and the current circulating in the cable. In spite of their ease of use, these standards do not take into account the real operating conditions. They furnish the previously mentioned dependencies in the case of single wires in free air. The same standards furnish a set of bundle derating curves, in which the hypothesis of homogenous bundles is made.

These standard dependencies are plotted for a single configuration in which it is supposed that all the equipment function in the same time. This assumption is not realistic in several cases, like:

- The case of equipment that have to work only during certain flight phases (landing gear, galleys, etc.)

- The case of equipment disposing of primary, secondary and emergency supply circuits (these cables should not be supplied in the same time).

Moreover, the standards do not take into account any differentiation between special cables.

It becomes obvious that these methods are obsolete and that the sizing of the cables should be rethought using new rules that take into account the real loading rate of the cables in the different bundles and the overheating corresponding to each type and gauge of cable. The second major component allowing the sizing of the cables is the electrical one. The choice of the gauges should be made with respect to the maximum voltage drop criteria imposed while considering the compatibility of the different cables composing the electrical link. Another important factor to be considered is the inductive character of the supply cables that cannot be neglected anymore due to the size of the gauges used and the increase of the normal functioning frequency. Last, but not least, the sizing of the cables should take into account the influence of the different flight phases and of the areas' in which the cable passes (pressure and temperature will vary depending on the area traversed).

In the new "more composite and more electric aircraft" context, the environment of the electrical wiring system is modified. The increase of the steady state functioning frequency leads to the increase of the inductive components of the conductive elements and of the mutual couplings between them that eventually have to be taken into account when designing the electrical system. The optimisation of electrical systems will take these aspects into account as an input data.

2. Scope of work

The aim of this call for proposal is to select a partner for the development of cable gauges optimization software. The partner selected at the end of the procedure shall have 18 months to provide a validated tool.

As presented in the previous paragraph, the cable gauge sizing problem is a multi-physics problem. Thermal and electrical aspects are to be taken into account in the first place, but the software should be conceived with regard to the possibility of introducing additional constraints, like considering the electro-magnetic environment created by the current return network, the structure of the aircraft, the fuselage, and the couplings that may occur between all these elements.

The wiring system in question is a large scale system, containing more than 1000 wire harnesses, 40000 pathway segments, 10000 connectors, corresponding to more than 150 km of cables. The electrical links between two equipment generally include several segments (pathway segments). These wire segments may have different gauges. The optimization of the different wire gauges is the scope of this study.

The choice of these gauges is subject to constraints like:

- flight phase durations
- variable environmental parameters (temperature, pressure) according to the zones of the aircraft
- electrical consumption cycle for each wire connection
- unknown and non-controllable position of wires in the harness
- impedance of the supply loop.

The WP leader has identified two major axes for this study that should be treated:

1° defining and developing some optimization techniques suitable for large scale systems; the objective function will be at first a mono-objective function - the minimization of the cable mass under constraints; the objective function may evolve to a multi-objective function by adding costs, for example.

2° developing a model reduction strategy and adapting the optimization process accordingly.

The WP Leader will provide all the necessary input data concerning the system to be optimized: system configuration, gauge range, data related to the environment, impedance of the supply loop (this data is furnished by the GENIAL project, JTI-CS-2011-1-SGO-02-032, on “Current return simulation (methodology & tool)”).

The first step will consist in the development of a global optimization strategy. Several methods will be proposed by the partner with an additional performance analysis. The partner will define a thermal and electrical model reduction strategy and will adapt an optimization process accordingly. At this moment, a hierarchical organization of the constraints in the optimization process seems a good solution for obtaining a sequential process that could be more easily computed. Only electrical and thermal aspects evoked previously, applied only to the supplied cables that have to be optimized, will be considered at the beginning. The partner will foresee the introduction of other constraints later.

The second step will consist in the development of optimization software. The input data provided by the WP Leader will be the standard charts and the electrical database of the WP Leader. An interface between the software and the electrical database of the WP Leader will be necessary.

3. Type of work

The selected partner shall deliver a methodology, a software tool and a user manual of the software tool.

The partner shall provide all the necessary resources (software expert, optimisation expert, etc.) to this proposal.

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

The partner should be experienced in large system optimisation problems.

The partner should have a strong, proven experienced in simulation software tools.

The partner should have his own developed simulation tools.

The partner should be able to upgrade and accomplish all maintenance works on the tools during the clean sky program.

5. Major Deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Description of the optimization methods and model reduction techniques		T0+ 6 Months
D2	First software release and associated user manual		T0+ 12 Months
D3	Software test and validation plan		T0+ 12 Months
D4	Validation procedure results		T0+ 18 Months
D5	Final software release		T0+ 20 Months
D6	User manual		T0+ 20 Months

6. Topic value (€)

The **maximum value** for this topic is

300,000 €*

[Three Hundred Thousand euro]

**Please note any proposal above this value will be NOT be eligible.*

7. Remarks

The electrical database for the study will be provided by the WP Leader in .xml file format.

Topic description

CfP Nbr	Title		
JTI-CS-2013-1-SGO-02-057	PWM High Voltage connectors	**End date**	December 2014
		Start date	July 2013

1. Background

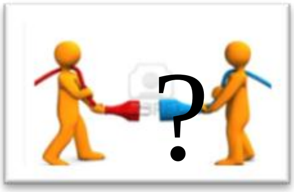
Since few years, to develop the more electrical aircraft, industrial works for the use of electrical systems in place of hydraulic systems for a lot of function requiring high load capacities.

This new approach involves the development of electrical materials which transported the high power to supply motors or actuators more numerous and more powerful. Therefore, the trend is to increase voltages to answer at the demand:

- For AC voltage: 230 V_{RMS},
- For DC voltage: +/-270 V,
- For *Pulse Width Modulation* (PWM) voltage: 540 V_{max} (compounded phase).

The increase voltage amplitude and apparition of new kind of signal (PWM) must be taking into account for sizing of harness components like connective devices, wires… They must be adapted to the characteristics of the new voltage and needs to be qualified according to the constraints for a use in all aircraft flight conditions and for all areas (pressurized or unpressurized).

Nowadays, rapid development of electricity on board require to transport this energy with unfailing. Connectors must be follow the tendency imposed; it is one of key point of this transmission. It not suffices to over-dimension it: it necessary to adapt it to electrical constraints but not only.



The aim of this call for proposal is to focus attention on connectors compliant with 540V PWM.

2. Scope of work

The call for proposal aims to select a partner that will be in charge of the study of new connectors able to withstand the constraints of the 540V PWM in an aeronautical environment.

This scope is divided in 5 points:

1- State of art
2- Technological barrier identification
3- Prototype conception with PWM specification
4- Capability to perform validation tests
5- Manufacture prototype

<u>1-State of art</u>

The first step will be to update the state of the art already delivered with the proposal.

Axis for a good bibliography research, you need to identify the new constraints applicable to connectors. For this part, partner must find and understand new electrical phenomena and their impacts on connector. Increase of voltage, new kind of voltage and different physic aspects have influence on connector to develop. Several points shall be studied:

- electrical constraints:

- MLI voltage:
  - Particularity of $\frac{dv}{dt}$≈1000V/µs,
  - With maximum amplitude of 540 V (compounded phase),
  - With switching frequencies between 10 kHz and 20 kHz to have a current fundamental frequency until 2 kHz (if inverter is command in voltage),
  - These frequencies will induce skin effect on wires; this effect will be taking into account in the conception of the connector.
- Current with non-sinus waveform,
- EMC are electrical consequences, which have impact on other systems,
- Partial Discharges are also a consequence of high voltage, this aspect influence directly the connector lifetime,
- Power will circulate in connector will be between 50 and 100 kVA. High voltage combined with high current will be stress connector insulator and pin locations.

- Other physical constraints:
  - Thermal constraint: taking into account the heating and concentrate current in little space.
  - Connection between wires and connector itself
- Environmental conditions:
  - Connector use into pressurized or unpressurized area of the aircraft. It will have an impact on connector technology.
  - Humidity condition must be considered.

It is not an exhaustive list, the work package leader and partner will establish it at the beginning of project.

2- Technological barrier identification

After to have studied bibliography in the domain, maybe a part of list has no studied or approached in state of art because they are specific point.

This second step will be to check technological barrier due to the new electrical stresses identified. It stays to demonstrate and validate particular point specific to PWM signals.

These particular points are:

- Electrical constraints with important $\frac{dv}{dt}$ due to commutation,
- Harmonics which are consequence of cutting voltage and waveform of current induced.
- Transition of current in connector with skin effect or proximity effect in cable.

This list is not exhaustive and will complete with work package leader and partner chosen.

Aim of this part is to extract information and propose specifications for technical solutions for upgrade components.

Connector which permits to response to these constraints shall be develops or improves.

3- Prototype conception with PWM specification

The following step consists to design a prototype. A by-product of the existing standards EN/MIL or a new type of connector taking into account lists said before (electrical constraints, other physical constraints, environmental conditions, and other stresses identified). To the conception, design connector must be improve:

- Connection system must be innovated,

- Its weight will be decrease,
- Prototype shall be innovated

4- Capability to perform validation tests

The fourth step will be to perform validation tests. Prototype will pass several tests in accordance with work package leader and partner to demonstrate the capability of the new design to withstand the identified constraints.

5- Manufacture prototype

The last step will be to manufacture and provide a numerous of connector pairs male/female. The quantity will establish in function of project budget.

3. Type of work

The selected partner shall deliver a complete study including the following tasks:

Updated state of art and analysis, (with respect to the one delivered with the proposal);

Detailed technical proposals; 3D design; prototype; validation tests plan and tests results; manufacturing.

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

This call for proposal applies to a connective devices manufacturer with innovative capabilities and an important knowledge in aeronautical field.

The partner should be able to study, design and manufacture the products.

5. Major Deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Further detailed description of the state of the art and constraints analysis	Results of 1st step	T0+ 3 Months
D2	Technical proposals and specification	Issued from 2nd step	T0+ 6 Months
D3	Validation test plan		T0+ 6 Months
D4	3D design of the samples	CAO study of classical and movable connectors	T0+ 9 Months
D5	Sample delivery		T0+ 12 Months
D6	Validation test results		T0+ 15 Months
D7	Manufacturing products		T0+ 18 Months

6. Topic value (€)

The **maximum value** for this topic is **200,000 €*** **[Two Hundred Thousand euro]** **Please note any proposal above this value will be NOT be eligible.*

7. Remarks

- The partner will benefit of the support and the expertise of SGO member proposing this topic in the field of aircraft wiring. - This call is dedicated to the study of the 540 PWM voltage, however it could be interesting for the partner to have a knowledge of HVDC studies done during the FP6 project MOET (http://www.eurtd.com/moet/PDF/MOET%20Publishable%20Executive%20Summary.pdf)

Clean Sky Joint Undertaking
SP1-JTI-CS-2013-01-SGO-02-058

Topic description

CfP Nbr	Title		
JTI-CS-2013-1-SGO-02-058	Optimize Power cable for Skin Effects	**End date**	December 2014
		Start date	July 2013

1. Background

Aircraft engines have historically generated and transported electric power at low voltage levels as this has provided a safe and reliable means of energy transport. With the advent of technology such as the More Electric Aircraft (MEA), there is an increased electrical power demand from the engines. The replacement of such systems with electrical alternatives will provide significant aircraft efficiency benefits resulting in better environmental performance due to reduced fuel consumption, gain in flexibility and health monitoring.

The concept of the MEA to All Electric Aircraft (AEA) where electrical power plays a prevailing role requires the development of reliable and efficient equipment.

The MEA represents recently the major driver for increasing the generation of the electric power. Moreover, it directs the research into new generations' options. Different electric power generation disciplines are used in aircraft. These schemes are summarized in the following:

- The constant frequency (CF) options are the most common. However, the need for unreliable gearbox to match between the engine speed and the generator requirements of fixed speed. The CF is alternatively termed Integrated Drive Generator (IDG).
- Variable Speed Constant Frequency (VSCF) DC link system is now the preferred option for the most new military application and some commercial aircraft. Currently, the range of VSCF DC link system has been widened due to the recent advancements in the field of high power electronic switches.
- Variable Speed Constant Frequency (VSCF) cyclo-converters convert directly the variable frequency AC input power with fixed frequency and magnitude. The power generation efficiency of the cyclo-converter increases as the lagging power factor decreases, which would be beneficial if this technique is applied to motor loads with significant lagging power factors.
- Variable frequency (VF), typified frequency wild, is the most recent electric power generation contender. The promising features of VF are the small size, weight, volume, and cost as compared with other aircraft electrical power generation options. However VF may pose significant risk at higher power levels, particularly with high power motor loads; furthermore, the cost of motor controllers required due to the variation in the supply frequency, need to be taken into consideration when assessing the VF.

Innovations in the area of power components as all components associated are required to enable realization of MEA.

The aircraft power system usually consists of a combination of 115 V 400Hz AC for large loads and 28 VDC for avionics, flight control and battery-driven vital services. However, adopting the new generation options as VF requires using power electronics to convert all the motor/generator outputs into a single high voltage DC distribution system. The value of the system voltage is suggested to be 270 or 540V. Using a high value for the distribution system has the advantages of reducing the weight, the size and the losses, while increasing the levels of the transmitted power. The exact value, however, is determined by a number of factors such as, the capabilities of DC switchgear, the availability of the components and the risk of corona discharge (or Partial Discharge PD) at high altitude and reduced pressure.

Electrical wiring provides links in various signals form between devices. This network, more and more significant and crucial, given the scope of its function, must be reviewed and adapted to the news constrains regarding the power transmission such as: High Voltage Direct Current (HVDC), High Voltage Alternative Current (HVAC) and Pulse Width Modulation (PWM).

For reasons bind to voltage level increasing, several signals nature and VF, the design and development of new cable requires adaptation to different types of signals and optimizing equipment's operations.

2. Scope of work

This proposal is part of further work carried out as part of Clean Sky. This acts to develop cables complying with aircraft requirements and having optimized functional characteristics. Two types of cable will be developed:

- Link starter-generator (feeders of power transmission AC/DC: PWM transmission in starter-phase/ AC transmission in generator-phase)
- Specific transmission of PWM

Innovation in the field of cable takes into account the skin effect optimization. This improves the conductor part of the cable, its topology and its behaviour to electric stress. The aim of this call of proposal is to design, develop and manufacture a new conductor of cable with optimized skin effect.

The aircraft systems use converters to drive power loads such as synchronous or asynchronous motors. This power is carried by cables call "Power cables" and covers a wide frequency range up to several 100Hz. The power cable currently used have cylindrical conductor part which, taking into account skin effect are not optimized for a weight. For example, the resistance to 2kHz of Aluminium AWG000 is doubled in comparison with DC resistance. However, high frequency signals are also transmitted by power cable and more specifically to switching frequency on the level of the order several 10kHz. It is necessary to construct a precise model and manufacturing power cable, taking into account various phenomena that appear when the frequency increases.

The news advances should be made in the conductor's performance considering the optimum operation conditions.

The partner selected at the term of this procedure, shall have 18 month to realize the prototypes at TRL5 level in justifying aircraft requirements. These schemes are summarized in the realization of power cable which the different steps are:

- The study of the state of the art including existing products, their application and the known models.
- The step of electric and thermal conductor modelling in the frequency range up 100 kHz and the conductor parametric models.
- The making of sufficient length of different prototype (3) gauges (AWG8, AWG2, AWG00) and two (2) specific gauges (TBD) optimized for operation in the band 0-20kHz (switching frequency included)
- The step of test and validation: Thermal, Electric, mechanic, strip
- The step of validation by justification: aircraft requirements
- The providing of coil (length 200m) for specific gauge (TBD)

This summary shows an overview. The prototype delivered should be adapted to existing electrical contact and permit to use crimping contact processes.

They define the characteristic of the cable diversity, reflecting their behavior according to stress. The variation of these parameters allows developing specific cable. The parameters' values will be studied in the state of the art and specified in the design specification.

In some case such as PWM transmission, the conductor part will be composed by the mixture of strands enameled thread with bares conductors. The combination of both will ensure an even distribution of current density.

The partner shall take into account some specificity relative to functional and environmental aircraft stress. This standard specifies the characteristics, test methods, qualification and acceptance condition of single –core electric cables (according to gauge) for general purpose with conductors in intended for installation in aircraft circuits. It defines also a maximum voltage and a frequency limit for operation. The cables shall be submitted for qualification tests such as: thermal endurance, tensile strength on conductors and strands, flexure endurance, deformation resistance, torsion, scrape abrasion, flammability, resistance to fluids, etc…The environment stresses are defined by atmospheric parameters variation such as pressure, temperature and humidity. This cable shall operate without

damage and in correspondence with their functional specification in the environmental specified by RTCDO.
The proposing SGO member would make different types of harnesses that will have specific and optimized features according to their configuration. Preliminary study will be conducted for implementation and development of prototypes.

3. Type of work

The selected partner shall write the state of the art, the specification in collaboration with SGO members, design and manufacture of the prototype.
The partner shall provide all the necessary resources (safety expert, respect of standards requirements, materials, etc.) to this proposal.

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

The partner should have a matured experience in design and cable development.
The partner should be experienced in manufacturing components.
The partner should have his own recognized (by the aviation community) tool.
The partner should be able to upgrade and make the implementation during the clean sky program.

5. Major Deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Further detailed description of the state of the art		T0+ 5 Months
D2	Parametric model of the conductor		T0+ 10 Months
D3	Validation of Test Plan		T0+ 11 Months
D4	Conductors prototypes		T0+ 12 Months
D5	Test report		T0+ 17 Months
D6	Specific conductor coil		T0+ 17 Months

6. Topic value (€)

The **maximum value** for this topic is
200,000 €*
[Two Hundred Thousand euro]
**Please note any proposal above this value will NOT be eligible.*

7. Remarks

SGO member provide the specification of requirements.
Validation Test Plan will be confirmed by SGO member
SGO member reserves the right to define the specific gauge
it could be interesting for the partner to have knowledge of the results and the achievements done during the FP6 project MOET (http://www.eurtd.com/moet/PDF/MOET%20Publishable%20Executive%20Summary.pdf)

Topic description

CfP Nbr	Title		
JTI-CS-2012-3-SGO-02-061	Technology development and fabrication of integrated solid-state power switches	**End date**	November 2014
		Start date	June 2013

1. Background

This activity will support the design, fabrication and evaluation of a highly integrated matrix converter. The converter will be based on fully bond-wire-less double-sided cooled *sandwich* power module technology. The activity aims to demonstrate TRL6 technology maturity and deliver a fully functional power converter. Sandwich packages have no bond wires, can be cooled from both sides delivering improved thermal performance and can be optimised to give exceptionally low parasitic inductance. At system level, unprecedented power densities, efficiency and reliability can be achieved. However, the assembly of such structures can be quite complex and its technology readiness level is dependent on a number of choices for the specifically selected packaging and cooling features.

The key target of this work is therefore to ensure the achievement of TRL6 technology maturity, by developing, delivering and testing optimum interconnect and cooling solutions. The Topic Manager is seeking a partner who can contribute to the targets detailed below.

2. Scope of work

1) Design study:

Prepare a fully justified electro-thermal and thermo-mechanical design for the planar module assembly process, addressing both Silicon (Si) and Silicon Carbide (SiC) technology and according to design guidelines provided by the Topic Manager.

2) Planar module fabrication and assembly:

Establish reliable technologies to realise contact features and interconnect posts on DBC (Direct Bonded Copper) or AMB (Active Metal Brazed) substrates and on the top metallisation of power devices.

The target minimum feature size is < 0.3 mm x 0.3 mm with a height of at least 0.5 mm. Materials, co-planarity and compliance to suit the chosen assembly process based on design study 1) and in service requirements. The applicant should have access to and be in a position to procure latest technology devices, both in Si and SiC and substrates; ideally, the applicant should be autonomous in finishing/preparing the devices for use in a sandwich type package (e.g., solderable/sinterable top-surface).

3) Integrated gate driver:

As part of this activity, the integration inside the power switch of a monolithically integrated driver stage will be investigated. The circuit design will be discussed and specified in collaboration with the Topic Manager. Monolithically integrated drivers will be fabricated and included in the same package as the power switch.

4) Cooling:

State-of-the-art cooling solutions will be investigated, including both passive and active options. In particular, special attention will be devoted to the development of jet-impingement direct substrate liquid cooled solutions. Heat-sinks will be manufactured and delivered together with the power switches to be assembled into a power system. The heat-sink will allocate a suitable number of basic switches to maximise modularity and ease of system assembly.

5) Power switch manufacturing route:

Establish a manufacturing and assembly process for the power switch suitable for TRL6 demonstration and higher.

3. Type of work

1) Design study:

A mixture of electro-thermal and thermo-mechanical simulation will be required to establish optimum design choices for the proposed substrate and module assembly. The study will encompass both Silicon (Si) and Silicon Carbide (SiC) based electronics.

2) Technologies for sandwich packaging fabrication at TRL6 level:

Investigate manufacturing and assembly processes including solder and solder-less solutions. Study optimum interconnect materials, geometries and sizes for a specific case-study and define optimum solutions for both Si and SiC power switches. Interconnect can include a mixture of soldered and non-soldered solid posts and will include both electrical/mechanical interconnects and thermal/mechanical interconnects.

3) Monolithic gate-driver design and integration

Investigate options for integrating in Si, SiC or Si-on-Insulator (SoI) as many functionalities as possible of a standard matrix converter gate-driver design.

4) Cooling:

A part of this activity will specifically target the design and fabrication of optimum cooling solutions, including jet impingement direct-substrate cooling.

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

The successful partner will have demonstrated expertise and manufacturing capability of solid-state power switches for the avionic/aerospace industry. They will be independent in manufacturing and/or sourcing the required assembly parts, including interconnects and heat-sink; the partner will have access to latest technology semiconductor power devices and substrates. 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 standard avionic specifications to ensure the achievement of TRL6 level.

The partner will have experience and be certified for the industrial development of power switches for avionic/aerospace applications and be confident with innovative interconnect, packaging and cooling solutions. The partner will include at least a power switch manufacturer of proven experience in the avionic domain, equipped and resourced to provide the type and number of modules required for programme evaluation. Finally, the partner will be able to demonstrate an established track record in working with industry and academia on power module technologies for aerospace applications.

5. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Detailed substrate and process design	Fully justified design including mechanical, thermal and life models	T0+ 3 Months
D2	Power switches	Samples of power switches to pre-agreed specification with Topic Manager available	T0+ 6 Months
D3	Cooling solution	Samples of heat-sinks/liquid cooler to match D2 available	T0+ 9 Months
D4	Monolithically integrated gate driver	Samples of monolithically integrated (i.e., single chip) gate-drivers available (1 per power switch at least)	T0+ 12 Months
D5	Prototypes at TRL4 specification	Integrated power converter cell available for functional testing	T0+ 16 Months
D6	Prototypes at TRL6 specification	Integrated power converter cell available	T0+ 26 Months

6. Topic value (€)

The **<u>maximum value</u>** for this topic is **650,000 Euro**
(Six Hundred and Fifty Thousand Euro)

Topic description

CfP Nbr	Title		
JTI-CS-2013-1-SGO-02-064	Cooperative System Design Simulation Environment for Energy System Applications	**End date**	T0 + 24 Months
		Start date	T0 (as soon as possible)

1. Background

The Systems for Green Operations ITD of Clean Sky aims to demonstrate substantial environmental and economic benefits of more electric aircraft systems technologies. The design and validation of such highly integrated systems urge the need for more co-operative development processes involving aircraft, engine, and equipment manufacturers. The design process has to be supported through advanced modelling and simulation capabilities. Therefore the goal of the consortium is to define standardised modelling methods and tools in each phase of the energy system design process. This is examined for instance in the Use Case: "*Development of a modular energy system simulation tool-chain*" as part of SGO WP2. In this example, collaborators from the aircraft industry use the FMI Standard [1] in order to integrate their models in a total system simulation. Whereas this work has largely been conducted successfully, it also revealed still on-going demand for more light-weighted and freely accessible simulation tools for collaborative modelling processes. In particular,

(a) the dependence on one specific tool vendor in the design process shall be greatly reduced,

(b) unit and regression testing shall be applied over different tools in order that models can be safely utilized in different tools,

(c) connecting models from different suppliers and simulation tools for a unified system simulation shall be possible in a freely accessible tool.

The basis to reach these goals within this CfP is PySimulator [3], a Python based, open source environment for simulating FMU's [1], and running other simulation engines such as Dymola or OpenModelica. The central idea of PySimulator is to provide a generic framework to perform simulations with different simulation engines in a convenient way, to organize the persistent storage of small and huge result data sets, to provide plotting and other post-processing feature such as signal processing or linear system analysis, and to export simulation and analysis results to other environments such as Matlab. The major innovation of PySimulator is its plugin system: Nearly all operations are defined as plugins with defined interfaces. Several useful plugins are already provided, but anyone can extend this environment by his/her own plugins and there is no formal difference to plugins already provided.

Thus, this open source tool can be used by each partner independently of any commercial simulation environment used for FMU generation.

2. Scope of work

In this CfP several open source plugins shall be developed for PySimulator along the goals from above. In particular:

A. UNIT and REGRESSION TESTING:

(1) Simulator plugin for one additional commercial simulation engine for Modelica models (such as MapleSim, SimulationX, or Wolfram SystemModeler; but not Dymola, since Dymola is already supported in PySimulator). There is an existing plugin interface for Simulator plugins in PySimulator. According to this interface the selected simulation engine has to be interfaced.

(2) Plugin to perform unit- and regression testing over two and more models in PySimulator (especially different versions of the same model, FMUs generated from the same model by different tools, simulating a Modelica model with different simulation engines). The test definition shall be defined with a GUI and textually by scripting. Output of a typical test is a report including a measure of the difference of the simulation results, detailed information about the differences and result plots.

(3) Parallelization of the simulation and analysis runs for unit- and regression testing on a multi-core machine.

B. SIMULATION of CONNECTED FMUs:

(4) Connecting FMUs (FMI standard version 2.0, [3]) textually and using at least a connection GUI. Handling of many input/output signals that need to be connected shall be possible. An automatic check has to inform if connections are not in line with FMI standard. The connection schema has to be saved for reloading it in a following session.

(5) Simulate connected FMUs from (4) both for Model Exchange and Co-Simulation including handling of algebraic loops for Model Exchange. This means especially to implement a Simulator plugin for the Co-Simulation Master algorithm that controls the FMUs for Co-Simulation. The already available Simulator plugin for FMUs for Model Exchange in PySimulator shall be used as basis for a Simulator plugin for connected FMUs for Model Exchange.

3. Type of work

The partner needs to have access to a commercial Modelica model simulator for (1). Further, handling of Functional Mock-Up Units (FMUs) is a key part of the work. The main code has to be implemented in Python and some parts possibly in C. The code has to include a documentation of it.

License

The complete software and documentation to be delivered have to be open source with a license not more restrictive than LGPL. Especially, the GPL license is not acceptable.

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

The partner has to have knowledge and proven experience in most of the following topics:

- Modelica,
- FMI standard,
- Python, also GUI programming,
- C,
- Dynamic system simulation,
- Parallelization of simulation runs,
- Co-Simulation,
- Algorithms from graph theory to evaluate connected blocks,
- Software to solve differential algebraic equations.

5. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	New Simulator plugin	New simulator plugin of a commercial Modelica model simulator (software)	T0+ 6 Months
D2	First prototype of a plugin for unit and regression testing	Plugin for unit and regression testing (software)	T0+ 6 Months
D53	Second prototype of a plugin for unit and regression testing	Plugin for unit and regression testing with parallelized simulation and analysis runs (software)	T0+ 12 Months
D4	First prototype of a plugin to simulate connected FMUs for Co-simulation	Prototype of a Simulator plugin for connected FMUs for Co-Simulation (software)	T0+ 15 Months
D5	Second prototype of a plugin to simulate connected FMUs for Model Exchange and for Co-Simulation	Simulator plugin for connected FMUs for Model Exchange and Co-Simulation (software)	T0+ 20 Months
D6	Final report and software	Report documenting the implemented features and constraints (document); and the final version of all plugins (software)	T0+ 24 Months

6. Topic value (€)

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

€ 250,000

[Two Hundred and Fifty Thousand euro].

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

7. Remarks

References

[1] MODELISAR consortium: Functional Mock-up Interface for Model Exchange, Version 1.0, 2010. www.fmi-standard.org.

[2] FMI for Model Exchange and Co-Simulation, version 2.0, Beta 4, Aug. 2012. Download: https://svn.modelica.org/fmi/branches/public/specifications/FMI_for_ModelExchange_and_CoSimulation_v2.0_Beta4.zip

[3] A. Pfeiffer, M. Hellerer, S. Hartweg, M. Otter, M. Reiner: "PySimulator – A Simulation and Analysis Environment in Python with Plugin Infrastructure", in Proceedings of 9th International Modelica Conference, Munich, Germany, Sept. 2012. Download of PySimulator: https://code.google.com/p/pysimulator/.

Quality

The implemented plugins will be tested during the work phase by the topic manager with aircraft use cases from CleanSky.

Application

- The topic value under 6. is the upper bound for the total budget (so the sum of funding and contributor expenses).
- CleanSky "Founding members" as well as "Associate Partners" within "CleanSky – Systems for Green Operations" cannot apply for this topic in the call. This rule excludes the following organizations: Aeronamic, Agusta Westland, Aircelle, Airbus, Alenia, Cranfield University, Dassault Aviation, Diehl Aerospace, DLR, EADS, Eurocopter, Fraunhofer, Galileo Avionica, Hispano.Suiza, Labinal, Liebherr, Messier, NLR, Rolls-Royce, Saab, Safran, Techspace Aero, Technofan, Thales, TU Delft, University of Malta, University of Nottingham, Zodiac.

Topic description

CfP Nbr	Title		
JTI-CS-2013-1-SGO-02-065	Modelica library of detailed magnetic effects in rotating machinery	**End date**	T0+ 24 Months
		Start date	T0 (as soon as possible)

1. Background

For future aircrafts, the trend towards electrification is expected to persist. Formerly hydraulic actuators will be backed up or replaced by electromechanical actuators.

The electrical generators gain importance as primary source of the systems' energy. For systems design and systems integration testing, these machines have to be simulated with different levels of abstraction. While the detailed design often makes use of FEM computations, system interaction is tested by simulators for physical modelling.

For the modelling language Modelica, some free models and libraries of electric machines exist with special emphasis on the machines' loss modelling. No ready-to-use libraries exist for the more detailed level, which is needed for harmonics and voltage waveform computation. In order to mature the motor and generator design process and enable a consistent design chain for these essential systems, a strong need for such a library is given. In addition to this demand, in the pre-systems development phase no easy to use tools are available for a quick layout of machines. It would be beneficial for a model based design process to estimate typical motor properties and generate models from such a tool.

2. Scope of work

In this CfP a Modelica library of rotating electric machinery with detailed magnetic effects and non-ideal flux coupling shall be designed. Furthermore an easy to apply predesign tool for motors shall be implemented.

In particular

Library of detailed rotating electric machinery incl. common machines as permanent magnet and externally excited synchronous machine and induction machine. Existing open libraries may be developed further. The applicant shall consider the topics (1) to (5), with reasonable balance of simulation speed and model accuracy. Topics (6) and (7) must be addressed:

(1) Adjustable levels of detail, spatial and fundamental wave/ harmonic phasor models

(2) Modelling of the magnetic path by lumped elements (incl. material properties, saturation, hysteresis losses, eddy currents, nonuniform airgap).

(3) Thermal modelling

(4) Consideration of winding schemes (integral/fractional slot winding)

(5) Consideration of the iron and teeth shape

(6) GUI for guided model design and automatic generation of the lumped magnetic network

(7) Demonstration of validity of the modelling approach against FEM (preferably hardware)

Basic motor design tool with generation of a Modelica simulation model for use in early design phases. Embedding of public domain design tool is admissible. In particular:

(8) The tool shall cover at least the permanent magnet synchronous machine.

(9) A GUI has to be provided with choice of basic design parameters and torque/power demand profiles and basic consideration of thermal effects/cooling)

3. Type of work

The partner needs to have access to a commercial Modelica model simulator.

License

The complete software, model and documentation to be delivered have to be open source with a license not more restrictive than LGPL. Especially, the GPL license is not acceptable.

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

The partner has to have knowledge and proven experience in the following topics:
- Proven know-how of object-oriented modelling language Modelica
- Proven know-how of magnetic and electrical modelling
- Capable to validate models on test rigs or have access to test data

5. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Technical concept of advanced machinery modelling library and proof of concept by first prototype	Progress report	T0+ 6 Months
D2	Second prototype of the library	Software	T0+ 15 Months
D3	Validation against measurements or FEM	Report	T0+ 18 Months
D4	Prototype of basic motor design tool	software and progress report	T0+ 22 Months
D5	Final report and software	Report documenting the implemented features and constraints (document); and the final version of all tools and libraries	T0+ 24 Months

6. Topic value (€)

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

€ 250,000

[Two Hundred and Fifty Thousand euro].

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

7. Remarks

Quality

The implemented library and tools will be tested during the work phase by the topic manager with aircraft use cases from CleanSky.

Application

- The topic value under 6. is the upper bound for the total budget (so the sum of funding and contributor expenses).

CleanSky “Founding members” as well as “Associate Partners” within “CleanSky – Systems for Green Operations” cannot apply for this topic in the call. This rule excludes the following organizations: Aeronamic, Agusta Westland, Aircelle, Airbus, Alenia, Cranfield University, Dassault Aviation, Diehl Aerospace, DLR, EADS, Eurocopter, Fraunhofer, Galileo Avionica, Hispano.Suiza, Labinal, Liebherr, Messier, NLR, Rolls-Royce, Saab, Safran, Techspace Aero, Technofan, Thales, TU Delft, University of Malta, University of Nottingham, Zodiac.

Topic description

CfP Nbr	Title		
JTI-CS-2013-1-SGO-02-066	HVDC fuses design, development, validation and integration	**End date**	June 2015
		Start date	June 2013

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. Definition:

1.1 State of the art of existing aeronautics fuses

2. Development:

2.1 Module definition & realisation

3. Validation:

3.1 Standalone module validation & testing

3.2 TRL demonstration

4. Integration:

4.1 Support integration & test into EPDS

The fuses shall be compliant with the following requirements:

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

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

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

4- The fuse opening time shall be lower than RCCB's.

5- The fuse shall be functionnal during 30 years or 50.000 cycles (switch from 0A to nominal current), whatever comes first.

6- The fuse maximum weight is 200g.

7- The fuse shall be as compact as possible.

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

9- The fuse shall pass the 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

Deliverable / Milestone	Title	Description (if applicable)	Due date
D1	Existing aeronautics fuses further detailed description of the state of the art		T0+ 4 Months
M1	PDR		T0+ 6 Months
M2	CDR		T0+ 11 Months
D2	Prototypes delivery		T0+ 12 Months
M3	Prototypes testing		T0+ 12 Months
D3	Test results analysis		T0+ 13 Months
M4	Conception correction and improvements identifications		T0+ 14 Months
D4	Updated prototypes delivery		T0+ 19 Months
M5	Updated prototypes testing		T0+ 19 Months
D5	Test results analysis		T0+ 20 Months
M6	Industrialisation		T0+ 21 Months
D6	Final report		T0+ 22 Months
M7	Technical support to integration & test of the fuses into EPDS		T0+ 23 Months

6. Topic value (€)

The **maximum value** for this topic is **400,000 €** **[Four Hundred Thousand euro]**

Topic description

CfP Nbr	Title		
JTI-CS-2013-1-SGO-02-067	Optimized Insulation for adapted Characteristic	**End date**	December 2014
		Start date	June 2013

1. Background

The advent of MEA needs equipment performance at all levels. In this context, electrical power plays a prevailing role and requires the development of reliable and efficient equipment. Aircraft engines have historically generated and transported electric power at low voltage levels as this has provided a safe and reliable means of energy transport. The new concept increases the electrical power and the materials' properties should be adapted.

The challenge of Electrical Insulation System (EIS) problem in aircraft is related to following events:

- More Electric Aircraft (MEA), in which a high number of functions, previously by hydraulic actuators, become electromechanical actuators today. Thus, some electrical equipment will be installed in critical areas. Therefore, the stress on insulating materials, related to its operating environment, increases.

- As supply voltage increases in the aircraft, the necessity of new electrical networks should be created in addition of standard 115VAC network and 28VDC network used for commercial loads. These new HVAC and HVDC network will supply new electrical systems new like protection systems, electro-mechanical actuators, motors control units and engine starters. The development of these new electrical architectures is a great challenge. So, these voltage levels are new physical phenomena appearing in aircraft systems and may impact EIS.

- The high amplitude values of HVAC and HVDC combined with the use of the electric power equipment (autotransformer rectifier unit, static converters ...) generate harmonics and electromagnetic pollution in environment of system. Thus, the insulating material can also provide another function besides its main function. This is an alternative solution that will reduce the shielding usually used for electromagnetic protection.

Insulation material is used on all electric equipment to ensure a barrier between different conductive parts, submissive to different voltage or currents levels. It plays a major role and paradoxically constitutes the weak link of the power electric chain. Innovations in the area of MEA concern all components and system. EIS material's characteristic must be adapted and optimized for each application.

For example, the cable EIS is composed of multilayers according to requirements. Each layer provides a specific function: Electrical, Mechanical, Thermal ... Different technologies are used for the EIS implementation: extruded cable or taping cable [Figure1]

Figure1: Example of implementation of EIS by taping technology

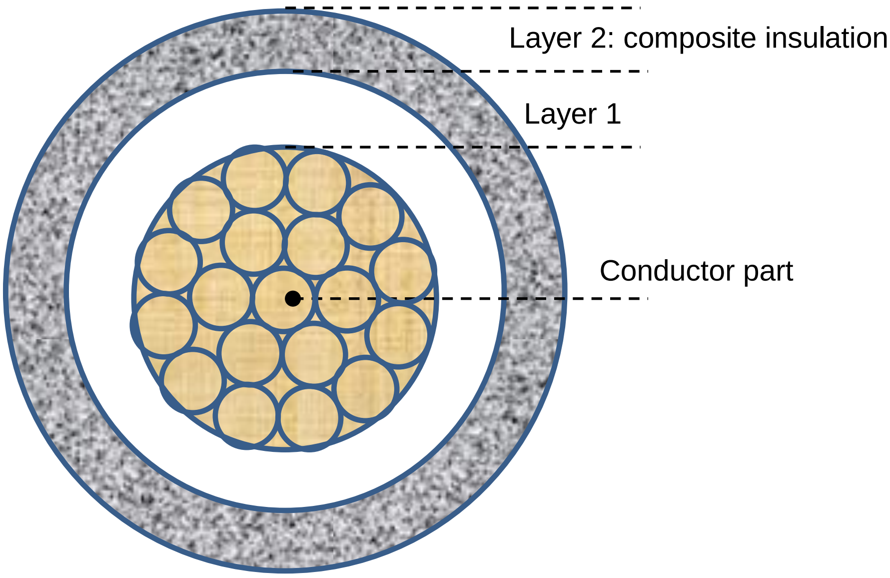
In view of this technology, each insulation layer can modify its properties to be adapted to a specific application.

Electric Insulation System (EIS) must evolve for insuring different functions. The new functionalities require the development of composite insulator. This insulator materials layers can play other roles besides their main functions, such as EMC protection and corona resistance, by modifying their characteristics.

For example, the variation of insulation characteristic changes also the transmission line parameters (RLCG). These challenges consist in elaborating of composite insulations (polymer matrix with ferrite powders reinforcement). It is necessary to have well control of the physical parameter variation of cable. This reinforcement will allow to modify insulator properties for specific application and to provide other functions such as partials discharges (or corona) resistance and could be also used, in some cases, to electromagnetic protection function.

2. Scope of work

This proposal is part of further work carried out as part of Clean Sky. This acts to develop new insulating material to comply with aircraft requirements and having optimized functional characteristics. The EIS is made up of multi layers. An insulated wire includes a conductor and an insulating coating on the periphery of the conductor. The insulating coating includes an insulating film formed by applying and baking polyester imides (Kapton) as Poly-Tetra-Fluoro-Ethylene (PTFE or Teflon) for second layer.



SIE cable example.

Innovation in the field of EIS cable would be to develop an insulation material which takes into account at least the EMC and RLCG characteristics of the complete link. The aim of this call of proposal is to study and manufacture a new wire insulating material with these functions optimized.

The partner selected at the term of this procedure, shall have 18 month to realize a cable tape (conductors + insulation) and a complete harness prototype.

These schemes are summarized in the realization of EIS, of which the different steps are:

- The update of the state of the art shall include the list of potential additive in insulation but also a list of existing product and their application.
- Technical proposition of development of composite insulating materials. The aim is to check, control the process of ferrite powder reinforcement and insulating materials behaviors on the following points:

  - shaping

- % reinforcement / miscibility (chemical aspects)
- % reinforcement / flexibility (mechanical aspects)
- % reinforcement / wire parameters variation (electrical aspect)
- % reinforcement / insulating materials behaviors (electrical aspects under stress)

- Definition of % reinforcement adapted to the specification (in collaboration with the topic manager)
- Test and validation: electric, mechanic, chemical, thermal,
- Step of validation by justification: aircraft requirements
- Providing cable tape (length TBD)

This summary shows an overview. The implementation on the conductor of the insulating will be envisaged for the different qualification tests.

They define the characteristic of the cable diversity, reflecting their behavior according to stress. The variation of these parameters allows developing specific wire.

The partner shall take into account some specifity relative to functional and environmental aircraft stress.

This insulating material shall operate without damage and in correspondence with their functional specification in the environmental specified by ABD 0031 – Flammability smoke and toxicity requirements.

Preliminary study will be conducted for the prototypes implementation and their development. This will integrate all components composing the wire and the techniques used.

3. Type of work

The selected partner shall update the state of the art already provided with the proposal, the specification in collaboration with Topic Manager

The partner shall provide all the necessary resources (safety expert, respect of standards requirements, materials, etc.) to this proposal.

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

The partner should have a matured experience in design and material development.
The partner should be experienced in manufacturing insulating material.
The partner should have knowledge aircraft requirements.
The partner should be able to upgrade and make the implementation during the clean sky program.

5. Major Deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Further detailed description of the state of the art		T0+ 4 Months
D2	Technical Proposition and associated action plan		T0+ 4 Months
D3	Insulator materials prototypes		T0+ 10 Months
D4	Technical & tests report		T0+ 16 Months

D5	Wire prototypes		T0+ 18 Months

6. Topic value (€)

The **maximum value** for this topic is **300,000 Euro** **[Three Hundred Thousand euro].** **Please note any proposal above this value will NOT be eligible.*

7. Remarks

Topic Manager provides the specification of requirements. Validation Test Plan will be confirmed by Topic Manager. Topic Manager reserves the right to define the specific gauge.

Clean Sky Joint Undertaking
SP1-JTI-CS-2013-01-SGO-02-068

Topic description

CfP Nbr	Title		
JTI-CS-2013-1-SGO-02-068	Harness integrated sensors network for wiring health monitoring	**End date**	January 2015
		Start date	July 2013

1. Background

Parallel to the More Electric Aircraft (MEA) development, the number of electrical components and equipment is increased

The electric harnesses are a critical element to ensure a nominal systems functioning during the operational phases and participate therefore to the safety of the mission. Face to its complexity, airworthiness requires considering harness like a system itself.

The harness is a physical component whose state evolves during A/C life, in spite of maintenance actions. Several studies lead in the United States showed that an aircraft of more than 20 years is virtually ensured to encounter a wiring problem.

A mean of controlling and preventing the wiring health (detection, localization, identification of defects) would enable to increase harness on-board diagnostic system efficiency.

Some detection methods were developed using a centralized detection: one measurement at one point. This kind of detection exhibits at least 2 problems:

Only clear defaults are detected (open/short circuit), and not the others like chafing. Only reactive action once the problem occurred is possible, excluding prevention

Defect location is inaccurate, particularly when a harness is made of different branches

2. Scope of work

The aim of this Call for Proposal is the development of a system monitoring harnesses defects, by implementing integrated and delocalized sensors network.

The goal of this project is to incorporate directly into a harness delocalized sensors, which each individually perform default detection in its vicinity. This easier detection also introduces more accurate localization. Inside the harness, sensors are organized in network, communicating together to report the health monitoring status to a central point.

Each sensor will

- ❑ embed a measurement/detection function,
- ❑ embed a communication function,
- ❑ and optionally be passive.

The harness will embed its own monitoring by integrating the built sensors network into the cable or the harness.

The global system (measurement exploitation, communication between sensor and maintenance central demonstration) is out of partner perimeter.

3. Type of work

The selected partner will be asked to work on:

• A state of the art of smart sensors, and particularly possible sensor integration technique, and potential energy harvesting mean to power up the sensor network.

The sensor parameters to measure, the range and accuracy will be discussed. For communication, wireless is foreseen, but another mean may be acceptable if it comply with the function. Care should be taken at the beginning of the study for using a sensor small enough to be integrated in the next step. To minimize the size, it may be acceptable to perform only very basic functions for demonstration.

All harness configurations from the simplest to the most complex (many branches connected together) shall be studied. To support this task, the WP leader will provide detailed and accurate tests cases.

- A technical proposal and a description of a technology to answer the WP leader request. Following this step, a design review will take place between both parts.

- A prototype will first be developed, without the complete electronic sensor integration but the proper functionality. This first prototype will be intensively tested and drive choices for next integration step.

- Then, a prototype demonstrating the electronic sensor integration into the harness will be provided

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

The partner should be experienced in smart, wireless, autonomous sensors. Products (or prototype) development evidence would be a positive aspect.

The partner should be experienced in aeronautical domain, or give evidence of activities in other similar domain which could give confidence that it already dealt with harsh environment and constraints.

The partner should particularly prove experiences in applicable standards as DO160 for environmental condition and DO254 for hardware development.

The partner should demonstrate skills and knowledge in cable and harness integration.

5. Major Deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Further detailed description of the state of the art		T0+ 4 Months
D2	Technical Proposition and associated action plan		T0+ 6 Months
D3	Non integrated prototype, to test only electronic and functional part		T0+ 15 Months
D4	Integrated prototype, mainly to test manufacturing and handling process		T0+ 21 Months
D5	Technology Perspective Plan		T0+ 24 Months

6. Topic value (€)

The **maximum value** for this topic is

500,000 €*

[Five Hundred Thousand euro]

**Please note any proposal above this value will be NOT be eligible.*

Topic description

CfP Nbr	Title		
JTI-CS-2013-1-SGO-02-069	High power SiC diodes for Starter-Generator rotating rectifier bridge applications	**End date**	February 2015
		Start date	September 2013

1. Background

Future Aircraft need more electrical power on board.

The associated electrical generator weight increase can be a drawback for MEA architectures. So generator manufacturers are looking for solutions to reduce the mass of these machines. Two of them are to increase their speed and power density. In this aim, new rotating diodes devices can be envisaged on the rotor of the machine. They combine three improved characteristics such as high junction temperature capabilities, low rectifying losses and high strains capabilities.

The existing PN Silicon dies have a maximum junction temperature of 180°C and their maximum stress capability prevents the rotor to be used over 24000RPM. The goal of this topic is to develop a die able to stand 50% higher stress, a current density improved by 20%, rectifying losses reduced by 30% regarding standard PN silicon die. This new substrate will have to be able to stand 230°C junction temperature.

2. Scope of work

1. To define the new die substrate,
2. To design new die,
3. To manufacture new die mock-up,
4. To characterize electric performances,
5. To evaluate mechanical and fatigue capabilities,
6. To evaluate robustness to an environmental representative stress.

3. Type of work

Task 1 (T0+2M): definition of the new die,

Task 2 (T0+6M): definition of the substrate material and die design able to satisfy specification of Topic Managers company,

Task 3 (T0+12M): deliver die mock-up according to the definition,

Task 4 (T0+18M): Evaluate electric, mechanical and robustness performance according to evaluation procedures specification jointly by the applicant and Topic Managers company,

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

The applicant will be able to:
- design and product dies,
- characterize electrical tests,
- conduct fatigue and combined robustness tests.

5. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Report on die definition		T0+ 2 Months
D2	Delivery of prototypes		T0+ 12 Months
D3	Report on performances		T0+ 15 Months

D4	Report on robustness		T0+ 18 Months

6. Topic value (€)

The **maximum value** for this topic is

600,000 €*

[Six Hundred Thousand euro]

**Please note any proposal above this value will be NOT be eligible.*

Topic description

CfP Nbr	Title		
JTI-CS-2013-1-SGO-02-070	New magnetic materials for rotating machines	**End date**	February 2015
		Start date	September 2013

1. Background

Future Aircraft need more electrical power on board.

The associated electrical generator weight increase can be a drawback for MEA architectures. So generator manufacturers are looking for solutions to reduce the mass of these machines. One of them is to increase their speed. In this aim, new magnetic materials can be envisaged on the rotor of the machine. They combine attractive magnetic characteristics and high mechanical properties.

The existing magnetic materials do not allow to manage both requirements. So maximum linear speed of wound rotor synchronous machines is limited to approximately 130 m/s. This value is expected to be increased by 30%, using the new magnetic material.

2. Scope of work

1. To define the new magnetic material,
2. To characterize its magnetic characteristics (losses at high frequencies and magnetic flux density) versus combined constraints as temperature and mechanical strength,
3. To characterize its mechanical characteristics (yield strength and fatigue due to the in-flight alternative stresses),
4. To realize laminations and manufacture two rotor stacks according to specifications of Topic Managers company.

Out of scope these two rotors will then be tested by Topic Managers Company.

- One rotor will be tested and driven up to its breaking speed,
- The second one will be integrated into a machine and electromagnetic characteristics of the new machine will be measured.

3. Type of work

Task 1 (T0+2M): definition of the new magnetic material jointly by the applicant and Topic Managers company.,

Task 2 (T0+8M): magnetic characterization (magnetic flux density versus combined constraints and losses at frequencies between 400 Hz and 1200 Hz),

Task 3 (T0+8M): mechanical characterization (yield strength and mechanical fatigue according to inputs coming from Topic Managers company.,

Task 4 (T0+18M): manufacturing of two rotor stacks, according to definition drawings supplied by Topic Managers company.

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

The applicant will be able to:

- supply the new material in different shapes (probes and laminations),
- conduct the required characterizations on several probes,
- manufacture two rotors

5. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Report on material definition		T0+ 2 Months
D2	Report on losses measurements		T0+ 8 Months
D3	Report on fatigue measurements		T0+ 8 Months
D4	Delivery of two rotors		T0+ 18 Months

6. Topic value (€)

The **maximum value** for this topic is

600,000 €*

[Six Hundred Thousand euro]

**Please note any proposal above this value will be NOT be eligible.*

Topic description

CfP Nbr	Title		
JTI-CS-2013-1-SGO-02-071	Bi-phase cooling system suitable for power electronics dedicated to more electrical aircraft	**End date**	T0 + 24 Months
		Start date	T0

1. Background

Traditionally, aeronautical power electronics use liquid and/or air forced cooling systems. These techniques are proven, reliable and robust technology but drawbacks are overweight and limited efficiency to extract heat flow generated in high power and dense converters.

This call for proposal consists on studying and developing demonstrators of cooling system based on biphasic techniques in order to reduce drastically thermal constrains, weight and dimensions of high dense power electronics modules (PEM).

This cooling technique, initially developed for space application, becomes promising solution for MEA concept that allow densification and growth of onboard power without overweight for thermal issue.

This CfP is a scientific and industrial challenge, which provides opportunity of competitiveness on this important improvement part of power electronics dedicated for more electrical aircraft for European partners of Clean Sky.

2. Scope of work

The objective of this study is to evaluate and to develop biphasic-cooling system for both power electronic converters units (PEM) and matrix of converters; this cooling system shall be suitable with aeronautic environment

This study shall include the following technical parts and activities:

a) State of the art & trade study of existing and advanced biphasic cooling techniques.

b) Selection and study of more adapted biphasic cooling solution for aeronautic electronic converter

c) Optimisation of thermal and physical (weight, size) performances of selected cooling solution by simulation,

d) Description of final hardware design solution

d) Validation tests of demonstrators

e) Manufacturing and delivery of hardware samples for internal verification and validation at aircraft levels.

3. Type of work

The activities of this work shall be limited to 24 month time 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+4M): Report of trade study of existing and innovative bi-phasic cooling techniques

Task 3: (T0+6M): Preliminary design review of technical proposal in accordance with specification

Task 4: (T0+9M): Detailed Analysis of down selected solutions and report of simulation study

Task 5: (T0+11M): Final design Review and start of HW prototyping.

Task 6: (T0+16M): Report of hardware tests performed at PEM level.

Task 7: (T0+18M): Delivery of minimum four hardware samples for internal verification and validation

Task 8: (T0+22M): Report of hardware tests performed at matrix of PEMs level (scalability of selected

solution) with prospective to extend the design proposal to the others topologies of converters.
Task 9: (T0+24M): Final report (synthesis and conclusion).
Progress reports will be requested every month.

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 biphasic cooling system,
- 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.

5. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Study Plan	Analysis of requirement and definition of scope of work	T0+ 1 Month
D2	Technical specification		T0+ 2 Months
D3	Trade study	Report of trade study of existing and innovative bi-phasic cooling techniques	T0+ 4 Months
D4	Detailed Study for selected cooling solution	Prelim design review	T0+ 6 Months
D5	Final Design Review	HW prototyping start	T0+ 11 Months
D6	Test reports	Performances evaluation	T0+ 16 Months
D5	Final reports	Conclusions and synthesis	T0+ 24 Months

6. Topic value (€)

The **maximum value** for this topic is

800,000 €*

[Eight Hundred Thousand euro]

**Please note any proposal above this value will be NOT be eligible.*

Topic description

CfP Nbr	Title		
JTI-CS-2013-1-SGO-02-072	Li-Ion Battery for optimized DC network power conversion	End date	T0 + 18 Months
		Start date	T0

1. Background

Traditionally, aircraft power system use passive power converter coupled with NiCad battery to provide power to 28Vdc buses from main AC network. The overall power quality from this architecture is fairly low and impact avionics loads designs and overall system reliability.

Recent progress in power electronics allows higher power density for active power converter solutions compared to traditional passive approach. The new solutions allow considerable performances enhancement and weight/volume savings (feeder, loads…) and better reliability at aircraft level. The active nature of the power converter allows also integrating multiple functions inside the same power core.

The emergence of Lithium battery with high power density performances pushes to re-architecture 28Vdc power system to include new lithium chemistry constraint (safety, Battery charger…). Management of lithium battery charge and discharge imposes multiples protections in order to insure a proper behaviour during all scenarios. No break power transfer coordination is also a challenge at architecture level.

2. Scope of work

The objective of this study is to develop a 28Vdc active power conversion / energy storage architecture including lithium battery constraint for new aircraft power system generation. This new architecture will leverage progress in active power conversion and mutualisation of function such as battery charger and TRU. The main objective of the development this new active power conversion system coupled with li-ion energy storage is:

1) Weight / volume optimizations at system level

2) Improvement of battery life

3) Optimization of RC for overall system

4) Optimization of DOC and DMC

5) No break Power transfer 28Vdc

6) Scalability and openness of solutions

This study of active power conversion / energy storage shall include the following technical parts and activities:

a) Updated State of the art & trade study of existing and advanced architecture.

b) Selection and study of limited architecture

c) Description of final hardware design solution

d) Validation tests of demonstrators

e) Manufacturing and delivery of hardware samples for internal verification and validation at aircraft levels.

3. Type of work

The activities of this work shall be limited to 18 months' time 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+1M):.Preliminary Report of trade study of existing and innovative architecture

Task 3: (T0+3M): Report of trade study of existing and innovative architecture and down selection.
Task 4: (T0+6M): Detailed Analysis of down selected solutions
Task 5: (T0+9M): Final design Review and start of HW prototyping.
Task 6: (T0+12M): Report of hardware tests performed.
Task 7: (T0+18M): Final report (synthesis and conclusion).
Progress reports will be requested every month.

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

The partner will have to collaborate with company of the Topic Manager in order to develop a new 28Vdc power system architecture based on integration of li-ion battery with active power converter. The company of the Topic Manager will develop the active power converter and the partner will provide strong expertise in Li-ion energy storage system. The partner shall have strong knowledge of Li-ion battery system including safety, aging, and performances optimizations. The partner shall have test, integration and simulation means for the development and the integration of the overall system. The partner will contribute to analyse different solutions allowing weight/functional optimization of 28Vdc li-ion battery used in association with active power converter while using novel implementation of security, monitoring and charge functions. For this study, the applicant shall satisfy following minimum criteria:

- Good background and experience in Li-Ion battery system,
- 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.

5. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Study Plan	Analysis of requirement and definition of scope of work	T0+ 1 Month
D2	Architecture Pre-study	Prelim trade study	T0+ 1 Month
D3	Architecture Down selection	Detailed analysis and architecture selection	T0+ 3 Months
D4	Detailed LRU Study for down selected architecture	Prelim design review	T0+ 6 Months
D5	Final Design Review	HW prototyping start	T0+ 9 Months
D4	Test reports	Performances evaluation	T0+ 12 Months
D5	Final reports	Conclusions and synthesis	T0+ 18 Months

6. Topic value (€)

The **maximum value** for this topic is

600,000 €*

[Six Hundred Thousand euro]

**Please note any proposal above this value will be NOT be eligible.*

Topic description

CfP Nbr	Title		
JTI-CS-2013-1-SGO-03-021	Flight Operations for novel Continuous Descents	**End date**	August 2015
		Start date	November 2013

1. Background

This topic includes assistance in preparation, execution and analysis of a flight simulator experiment as well as flight tests.

The Systems for Green Operations ITD (Integrated Technology Demonstrator) of Clean Sky aims to demonstrate substantial environmental and economic benefits of new on-board systems and functions. Apart from the so-called "Management of Aircraft Energy" (MAE) those improvements will come from improved "Management of Trajectories and Missions" (MTM).

For the latter a Flight Management System (FMS) optimisation and guidance function is under development for Continuous Descent Operations (CDO), which is based on Time and Energy. This novel function takes multiple parameters into account and is called: Multi Parameter Guidance with **Time and Energy Managed Operations (MPG-TEMO).**

The innovation of MPG-TEMO, certainly with respect to current CDO's, is to allow, as much as possible, idle-thrust descents through energy modulation. MPG-TEMO will cater strict time constraints, thus bringing the environmental and economic benefits of CDO's to all-day operations.

This call for proposal is meant to find a partner who can contribute to maximum two flight simulator experiments with respect to operational, safety and certification perspectives.

The results of this work will be input to a flight-test program, which is a second part of this work.

2. Scope of work

The aim of this Call for Proposal is to select a partner who is able to bring additional innovation to Continuous Descent Operations to the flight deck from operational, safety and certification perspectives. Thus to identify issues in these fields and to come with plans how to address those issues, possibly in a novel way.

The technical content, i.e. main implementation of such a MPG-TEMO function into the FMS will be performed by other parties. The work described herein is to help define, prepare, perform and analyse maximum two flight simulator experiments, which will be a prerequisite to the Flight-Test. Furthermore the partner is supposed to support the a/c integration process prior to the Flight Test and with the final test result analysis.

Together with the technical contributors the co-operation with the selected partner is to improve the maturity of this MPG-TEMO function from Technology Readiness Level (TRL) 4 to TRL 5 with the simulator experiment and towards TRL 6 with the Flight tests.

The work can be clarified in more detail:

a) Determine issues in the operational/safety and certification fields, followed by a plan how to address them. I.e, some of those issues can be verified in the simulator experiment.

   Advice on improvements of the MPG-TEMO function regarding these issues must be dealt with by the technical partners as far as possible.

b) Definition and selection of appropriate scenarios for the simulator experiment and flight testing. Critical situations for the MPG-TEMO functions from the Flight Operations/Safety/Certification point of view are of interest.

c) Recruitment of qualified flight crews. Select and schedule flight crews for the simulator experiments. All costs related to the participating flight crews must be included in the bid. It is assumed that a partner's staff-member is present at the simulator on all experiment days. E.g. for additional explications to the flight crews and to collect all relevant data and notes required for the analysis. The flight simulator experiments will take place at NLR Amsterdam (The Netherlands) and at DLR Braunschweig (Germany).

d) Analysis. The participating subject pilots will file comments by questionnaires per simulated scenario flight as well as an overall questionnaire and through a debriefing. Similarly for the flight tests. The partner will analyse all the comments to derive a general conclusion and the recommendations for improvements on the MPG-TEMO function. The partner is responsible for the Analysis from Flight Operations perspective in close co-operation with MPG-TEMO developers' team that will perform the Technical Analysis.

e) Project pilot technical and management activities. In addition to the above defined tasks, the project pilot will need to be involved in verification and validation activities and plan to include certain periods for this. Also, the minimum project management activities necessary to establish proper communication and project control will have to be carefully defined and included in the bid. Like minimum and maximum number of foreseen progress meetings, quarterly progress reports, number of expected travels, travel and hotel/accommodation costs, minimum and maximum number of on-site attendance days for experiment and potentially for concept dissemination days, etc.

3. Type of work

The type of work requested in this call for proposal is to develop new flight operations for implementation as of 2018 and beyond, especially related to Continuous Descent Operations (CDO).

Additionally the type of work is to help validate by means of maximum two flight simulator experiments and a flight test an innovative FMS optimisation & guidance technique for CDO, called MPG-TEMO that is based on the management of time and energy simultaneously.

Apart from supporting the simulation experiment also work is requested in the preparations of the flight test, this with respect to operational/safety and certification issues, related to an experimental set up **not** consisting of a real avionics architecture. Furthermore, the partner should assist in achieving TRL5 (flight simulations) and TRL5+ (flight test) matters related to major certification and architectural integration aspect of the new MPG-TEMO concept into the cockpit. This will need to be analysed and reported.

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

The candidate partner, which may be a consortium, must be able to deliver a project leader, a project-pilot and flight crews.

The project leader is responsible for overall project management and the deliverables.

The project-pilot has a long experience in flying commercial aeroplanes, but he may be retired from active flying. He, or his team, has a background in Flight Operations and in conducting Human (i.e. pilot) in the loop experiments and is the main operational point of contact for the MPG-TEMO developers. Experience in aircraft cockpit system certification is preferred but not mandatory. Applicants are expected to provide a track record on these matters.

5. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1 (a &b)	Flight scenarios to validate MPG-TEMO in two flight simulator experiments.	Based on the planned Flight-Test trials, and based on the foreseen flight simulator tests in NLR and DLR.	T0+ 3 Months
D2 (a&b)	Pilot briefing guides to participate in the MPG-TEMO flight simulator experiments.	Includes Flight procedures for the foreseen flight simulator tests in NLR and DLR.	T0+ 6 Months
D3 (a&b)	Flight Operations Analysis of the MPG-TEMO flight simulator experiments.	Qualitative operational assessments for the foreseen flight simulator tests in NLR and DLR.	T0+ 11 Months

D4	Assessment of the MPG-TEMO concept with respect to operation/safety and certification as prerequisite to perform a Flight-Test	An assessment of those aspects that may come into play during a Flight-Test execution.	T0+ 15 Months
D5	Flight-Test Analysis	For the aspects described in D4	T0+ 22 Months
D6	Certification aspects and solutions for the MPG-TEMO avionics integration concepts	TRL5 and TRL5+ related certification aspects and solutions for the MPG-TEMO concept integration into the cockpit avionics.	T0+ 22 Months

6. Topic value (€)

The **maximum value** for this topic is

500,000 €

[Five Hundred Thousand euro]

Please note any proposal above this value will be NOT eligible.

7. Remarks

The bid must include all travel and subsistence costs to the Netherlands and Germany.

Expected number of on-site attendance days are:

A. for the simulator integrations and check-outs:
- Ten (10) working days in total per flight simulation experiment at NLR and DLR

B. during the flight simulator experiments:
- Three (3) full weeks at NLR-Amsterdam
- Three (3) full weeks at DLR-Braunschweig

C. for the flight test integration / advice on certification aspects/ result data discussions
- Ten (10) working days

D. Days for consulting, management and technical progress meetings (to be defined yourself)

Invited flight crew costs, like travel and subsistence (under B) need to be paid from the project budget.

Topic description

CfP Nbr	Title		
JTI-CS-2013-1-SGO-03-022	Validation of avionic polarimetric radar X-band meteorological models and algorithms through experimental tests.	**End date**	December 2014
		Start date	July 2013

1. Background

The Clean Sky Systems for Green Operations ITD, and in particular the Management of Trajectory and Mission (MTM) work package aims to demonstrate that the achievement of pollution reduction can be supported by more precise, reliable and predictable Green Trajectories, optimised for minimum noise and emissions in each flight phase, including agile trajectory management in response to unattended events, (e.g. the insurgence of unforecast weather phenomena).

In this framework, the Topic Manager has been developed new radar signal processing algorithms for avionic polarimetric radar data, able to better classify the weather phenomena in terms of content and spatial resolution also making use of Artificial Intelligence for trajectory optimization.

Two projects, namely CLEOPATRA and KLEAN, have been also sponsored by the JU-SGO for providing radar signal models and implementation on EFB respectively to test the algorithms in a simulation framework. In all these activities the main critical point is the absence of real data to validate both models, algorithms and EFB in a real scenario.

In fact, C-band ground polarimetric radar are the most available in Europe with some few exception for ground X-band polarimetric radar, but they are not really useful for the aim of avionic models and algorithms validation because of the use of stationary platform and the difficulty to correlate phenomena observed from very different angles of view.

Therefore, an ad hoc measurement campaign for the acquisition of X-band avionic polarimetric radar data from an airborne platform of weather phenomena in cooperation with ground–based weather radar, besides the innovative character of comparative measurements not yet performed in Europe, is mandatory to test models and algorithms implemented on EFB (Electronic Flight Bag) and to assess with greater reliance the A-WXR TRL5 achievement in Topic Manager activities.

2. 2. Scope of work

The use of polarimetry in the new generation of avionic X-band radar should provide better performance for the characterization of weather phenomena, allowing the pilot to avoid the hazardous turbulences with closer trajectories with the advantage of saving fuel and noise pollution.

To quantitatively demonstrate the real benefits of radar polarimetry in the MTM, Topic Manager has been developing some new radar signal and data processing algorithms for weather classification as well as quasi artificial intelligence tools for trajectory optimization that will be tested on radar signal models developed in the CLEOPATRA project and on EFB through the KLEAN project (projects assigned to third parties through a call). Models and radar signal simulators for testing algorithm provide useful indication of the expected performance but they obviously suffer of the approximations of weather modelling, polarimetric e.m. scattering and absorption models, radar subsystem schematization (mainly antenna beam and scan patterns) and operating mode reproduction (stop and go techniques are often employed). Therefore, to have a much reliable analysis of algorithms and validation of models, an experimental activity involving avionic X-band polarimetric radar is highly advisable.

The subject of the call shall be the planning, execution and data analysis of a measurement campaign by means of an airborne polarimetric X-band radar for the validation and reliability tests of models and algorithms for weather classification and trajectory optimization.

The work can be divided into the following 8 steps to be further detailed under Topic Manager specifications:

1. Survey of the available X-band polarimetric radarsable to be installed on board of an aircraft and

airborne platforms for housing the radar
2. Radar updating and purchasing or renting
3. Airborne platform selection and radar installation
4. Measurement set up testing
5. Definition of a measurement campaign, including the use of a meteorological X-band ground radar for measure comparison and a weather forecast system
6. Experiment execution and data acquisition
7. Validation of models, radar-based weather classification and trajectory optimization algorithms through data analysis, based on quality and performance indexes.
8. Models, weather classification and trajectory optimization algorithms refinement in order to assess the achievement of TRL 5 by Topic Manager A-WXR and Q-AI solutions.

Documentation: The following type of documentation (detailed in section 5) shall be issued during the programme development:

a) Periodic Progress Reports
b) Technical Reports
c) Measurement data archives
d) Software Description including flow charts and I/O data formats of the routines.

3. Type of work

Preliminary analysis about available airborne and ground-based radars.
Radar and platform purchasing or renting
Measuring equipment set up and test sessions execution
Experimental data analysis
Models validation and weather classification and trajectory optimization algorithm's refinement with updated SW delivery

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

The applicant shall demonstrate to have the below special skills and equipment:

1) Familiarity with avionic X-band radar to have the capability for selecting and updating the radar to be used

2) Availability of airborne platform for housing the radar or capability to select companies able to provide the airborne platform for radar

3) Experience in measurement campaigns with airborne radars

4) Expertizes in meteorological polarimetric radar signal modelling and processing as well as in optimization problems and experimental data analysis.

5) Capability of SW development and test

A research team with deep skills in all mentioned scientific fields is required to cover every aspect of the project. In addition the applicant must prove their expertise describing previous experiences in such fields.

5. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1.n	Periodic Progress Reports	Reports on the work in progress will be issued at regular time intervals (every three-months), describing the activities performed and the results obtained in the period, as well as the progress on next deliverables and review milestones.	T0+ 3 x n Months
D2	Statement of Work	Description of the different activities in which the overall programme must be divided (WBS) and for each WP the allocated resources and costs, the time schedule and the relationship with other activities. Such document must confirm the WBS presented in the proposal (see section 7) and must be agreed with Selex-Galileo.	T0+ 0.5 Month

D3	X-band avionic radar selection and acquisition	Different X-band polarimetric weather radar available in EU shall be reviewed togerher with the specification and availability of the airborne platform housing the radar. A specific radar will be selected and purchased or rented with the assurance that the radar characteristics well match the reference radar architecture and operating modes used in models and algorithms development	T0+ 2 Months
D4	Measurement campaign plan and execution	Document describing the measurement set up and the measurement planning in different weather scenarios. The experiments must include the use of the X-band avionic radar, an X-band ground-based avionic radar (for a preliminary measurement analysis and cross-check) and a weather forecast system. Other meteorological sensors for wind intensity, barometric pressure, humidity and other must be used during the measurements.	T0+ 7 Months
D5	Validation of models, radar-based weather classification and trajectory optimization algorithms	Technical report describing the results of experimental data finalized to the validation of the radar signal models, radar-based weather classification and trajectory optimization algorithms both running on the EFB. The model and algorithm performance must be evaluated by defining ad hoc score indexes.	T0+10 Months
D6	SW refinement	Technical document describing the modifications of the SW implementing the models and algorithms provided by Selex-Galileo, after the refinement coming out form the real data analysis.	T0+12 Months

6. Topic value (€)

The **maximum value** for this topic is
1,000,000 €
[One Million euro]

7. Remarks

Management policy:

- In proposal the applicant must provide a Gantt diagram of the work, dividing the required activities in clearly defined work packages and indicating for every WP time schedule, required input and delivered output, in accordance with the scheduled deliverables listed at the previous section 5.
- Management & progress meetings shall be periodically planned during the entire project to evaluate activities progress, agree on requirements and results assessments, prepare milestones and reviews, and deal with project management issues.
- Further technical meetings shall take place on SGO Topic's manager request, in order to discuss in details specific technical points.

Clean Sky Joint Undertaking
SP1-JTI-CS-2013-01-SGO-03-023

Topic description

CfP Nbr	Title		
JTI-CS-2013-1-SGO-03-023	Simulation of Pilot Behaviour and Clearance Negotiation in Trajectory Changes Management	**End date**	December 2014
		Start date	July 2013

1. Background

Clean Sky SGO MTM project objectives and context of the topic

The System for Green Operations research consortium of CleanSky 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 (mainly CO2 and NOx) emissions and Noise. One of the main fields of research considered by MTM to reach these objectives is to optimize in-flight trajectories, including the overall missions profiles, through mathematical optimisation and suggest to the pilot in very short time a new trajectory required by the insurgence of a compelling unforeseen event. Obviously the pilot cannot be excluded by the decisional loop and must continue to have the full authority on the trajectory to execute.

The true advantages for the pilot of such a Decisional Support System, in terms of saved time to the decision, in terms of psychophysical stress and in terms of reduced emissions, should be accurately evaluated and quantified. At first glance, remarkable savings may be assumed especially in complex flight phases requiring extensive communications between ground and pilot.

For a comprehensive numerical evaluation of the advantages in the overall decisional process, from the detection of an event requiring an immediate decision in terms of changes to the reference trajectory up to the actuation of the new trajectory, a step-by-step simulation of pilot's behaviour and involved procedures should be performed for every flight phase.

Theoretical context

In order to study the behaviour of pilots in facing unforeseen events and make easier the decision making to tackle the new situation, in recent years many behavioural models have been studied also to correct the psychological profiles of pilots aimed to reach an unbiased and aware decision, taking into account the whole aspects and parameters of the unforseen arisen problem.

All the most complete decisional schemes, like DECIDE (Detect-Estimate-Choose-Identify-Do-Evaluate) and 3P (Perceive-Process-Perform), follow an iterative path starting from the detection that something has changed in the perceived scenario up to the undertaking of the needed actions to handle the new situation and the evaluation of their effects.

In such a context, a valid help can be provided by an equipment able to evaluate in almost real time a new trajectory optimized in terms of emission and noise minimization and suggest it by means of a friendly MMI for a ready and easy interaction with the Decision Maker.

In addition, having in mind the present and future ATM environmental, the procedures for having clearance by ATM to undertake the new propopsed trajectory should be accurately evaluated too, for calculating the advantages – mainly in terms of time saving – of adopting such a new equipment by comparison to the lack of it.

2. Scope of work

Description of work

The call is aimed to contribute to solve the problem of characterizing by analysis and simulation the pilot's behavior in decision making when unforeseen events force to a change in the reference trajectory with or without the help of an on-board Decision Support System (DSS).

The first goal of the proposed subject is therefore the quantification of the advantages of such an interactive tool aimed to suggest to the pilot the most suitable trajectory for overcoming the new event, optimized for minimum pollution through emission reduction and noise abatement.

An exhaustive set of operating scenarios both in cruise and during landing and takeoff shall be built according to the different dangerous situations caused by unforeseen phenomena forcing the trajectory change (hazardous weather, traffic congestion, runway unavailability due to poor visibility or adverse winds or windshear , etc…).

The interaction with the Decision Support System and the Air Traffic Control shall be simulated step-by-step, starting from the detection of the situational change needing a counteraction up to the final pilot's decision, by means of a suitable interactive Flight Simulator and evaluated in order to study the different possible actions the pilot can undertake to manage the change and the related effects. In order to add realism to the simulation environment, the system used for this call should be composed of multiple flight simulator capable of trajectory changes and one or more controller positions to cover different ATC units. In this way, controller may need to coordinate different requests at the same time and trajectory changes management between the pilot and the controller is affected by other pilots needs, as usual in a real environment.

In particular models for the behavior of different psychological pilots profiles in facing unforeseen situations should be simulated according to their psychophysical classifications found in dedicated literature and to the capabilities and performances of the aircraft.

In addition, assuming the use of a complex and complete flight simulator able to emulate the operating procedures between the pilot and the Air Traffic Control, once the pilot's decision has been taken about the new trajectory, the step-by-step negotiation with the proper ATC, according to present and future ATM scenarios, shall be emulated in real time to evaluate the time required for the operating procedure to obtain the clearance for the new trajectory taking into account also the hints of the DSS. Both voice communication system and data link enhanced capability should be taken into account as different means to exchange information between ground (ATC) and flight (pilot) - e.g. making extensive use of CPDLC messages, according to present and future ATM environment, aimed to promote digital communications for routine operations such as clearance, routing instruction,maintaining voice communication as a back-up in time critical circumstances.

By comparison between the results obtained with and without the use of the on-board Decision Support System (e.g.: installed in the Electronic Flight Bag for maximum interactivity), the time saving and the pollution reduction in the overall process shall be derived.

3. Type of work

Study and simulation work to evaluate the pilot's behaviour in all the steps from the detection of an occurred change in the environmental situation of the aircraft up to the actuation of the selected actions to face the new situation, with close attention to the interactions with a skilled Decision Support System and with the present and future ATM concepts for the required clearance.

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

The candidate organization shall own a complete Flight Simulator on which extensively simulate the pilot's behavior in facing new unforeseen situations and the subsequent steps in decision making, including the interactions with the ATM.

The candidate organization shall also be skilled in the procedures for negotiating with the ATM the new trajectory in present and future scenarios.

5. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1.n	Progress Report	Bimonthly Progress reports describing the activities performed in the period and the schedule for the next period activities.	T0+ 2 Months …T0+ 16 Months
D2	Problem Assessment	Assessment of the problem describing the capabilities of the owned Flight Simulator, its requirements for addressing the proposed work and the needed modifications to emulate the pilot's behaviour and the link with ATM.	T0+ 2 Months
D3	Further detailed description of the state of	Description of the most used Decision Making Process and of the procedures to negotiate trajectory changes at present time and in the future scenario.	T0+ 4 Months

Deliverable	Title	Description (if applicable)	Due date
	the art		
D4	Test Plan	Description of the scenarios to evaluate the pilot's behaviour and the performances of the Decision Support System in the different test cases.	T0+ 9 Months
D5.n	Test Reports	For each proposed scenario, the result of related tests shall be provided, including the description of the pilot's behaviour in facing the presented situation. Possible improvement to the Decision Support System in helping in the situation shall also be proposed.	T0+ 9 Months ….T0+ 17 Months
D6	Final report	Summary of all the activities performed during the overall work, including a detailed analysis of the results of the tests in the different scenarios with: • Evaluation of the advantages of the Decision Support System able to suggest to the pilot an optimized trajectory in terms of time saving • Evaluation of the advantages of the Decision Support System in pollution reduction • Evaluation of the advantages of the Decision Support System in negotiation process of the new trajectory with the ATM.	To+ 18 Months

6. Topic Value

The **maximum value** for this topic is

550,000 €

[Five Hundred and Fifty Thousand euro]

7. Remarks

Reporting

Progress reports will include by the following elements:

- Description of activities performed
- Numerical simulation / Technical issues
- Status of the next deliverables and review milestones

Meeting and review policy

- Management & progress meetings shall be planned at the issue of each Progress Report to evaluate activities progress, agree on requirements and results assessments, prepare milestones and reviews, deal with project management issues and discuss in details specific technical points.
- Each deliverable shall be submitted to the Topic Manager and issued after his approval.

Topic description

CfP Nbr	Title		
JTI-CS-2013-1-SGO-04-006	Thermal and electrical Mock-ups for Thermal Management of a Ground Integration Test Rig	**End date**	September 2014
		Start date	August 2013

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

2. Scope of work

A set of power electronic devices shall be developed and built that enables to simulate the electrical behaviour of various loads (at various frequencies) with defined and programmable load profiles. The devices shall offer the possibility to simulate/control the thermal behaviour of these loads and connect various cooling systems. These loads shall be programmable. In addition the converted energy shall be fed into the electrical network of the building.

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

1. Programmable electrical loads simulating consumers that are connected to liquid cooled power electronics modules. These shall complement the above mentioned loads ECS pack and VaCS. They shall be programmable to act as different additional loads such as main engine start, Fuel Tank Inerting System Motor, and commercial loads.

The loads are supplied with AC, voltage and frequency are adjustable by the existing Power Electronic Modules in the Electrical Power Distribution Centre (EPDC). A data connection to the power electronics controller shall be established.

The required load capability of one simulated consumer shall range from 30 kW up to 90 kW.

The total load capacity shall be approximately 150 kW.

The loads shall be set up in a modular way in order to cover the different load levels, i.e. several modules shall be able to be coupled to act as one load to the power electronics centre.

The loads shall be programmable in a way that a profile load vs time can be applied to each simulated consumer.

2. Programmable electrical loads simulating consumers that are directly supplied by +/- 270 HVDC. The aim of these loads is to provide a representative load to the HVDC supply and therefore to its cooling system.

The required load capability of one simulated consumer shall range from approximately 10 kW up to 70 kW. The loads shall be set up in a modular way in order to cover the different load levels, i.e. several modules shall be able to be coupled to act as one load to the power electronics centre.

The loads shall be programmable in a way that a profile load vs. time can be applied to each simulated consumer.

Both packages together shall – together with the existing loads from outside this call – deliver a full set of loads for the to be cooled electrical power centre in the test rig. This will allow to investigate and demonstrate the associated thermal management system, consisting of the liquid cooling system and the system to cool air cooled parts of the power centre.

Both types of loads shall be able to feed their consumed electrical energy back into the electrical supply system of the test rig facilities in order to save energy consumption of the facilities.

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

Deliverable	Title	Description (if applicable)	Due date
D1	Acceptance and contribution to the specification		T0+ 2 Months
D2	Architectural Design		T0+ 5 Months
D3	Detailed Design		T0+ 7 Months
D4	Equipment delivery		T0+ 11 Months
D5	Putting into service		T0+ 14 Months

6. Topic value (€)

The **maximum value** for this topic is
1,200,000 €
[One Million and Two Hundred Thousand euro]

Topic description

CfP Nbr	Title		
JTI-CS-2013-1-SGO-04-007	Design and manufacturing of a 10 kW AC-DC converter unit	**End date**	September 2015
		Start date	September 2013

1. Background

In the frame of Clean Sky SGO, innovative aircraft electrical networks are developed in order to support the More Electrical Aircraft concept.

A new complete electrical architecture must be implemented and tested to answer the challenges of a high power network.

The foreseen electrical network will be demonstrated in SGO WP4.2 on a highly representative test rig where it is planned to reach Technology Readiness Level (TRL) 5 for main critical components.

One of the key axes to achieve a successful electrical distribution is the use of power converters to adapt the sources' capabilities to the loads' power requirements.

As a consequence of a power rationalized aircraft, where electricity becomes the main power source for the aircraft systems, the use of different power converters is mandatory. To ensure high availability of electrical bus bars and so that dependence on a particular type of equipment cannot exist, it is foreseen to ensure power conversion dissimilarity to generate 28Vdc: DC/DC converters (±270Vdc / 28Vdc) and AC/DC (230Vac / 28Vdc).converters will be used on the test rig This choice allows electrical reconfiguration in case of failure in High Voltage Direct Current (HVDC) network, and ensures a double-separated-dissimilar 28Vdc power supply.

The use of transformer-rectifier units is state-of-the-art for current aircraft designs to accomplish this AC/DC power conversion. Nevertheless, for the future aircraft, weight and thermal optimisation become critical; this means that a strong technological step must be performed from the current state of the art, which has not evolved during last years as fast as for other static converters.

Current requirements for TRU (Transformer Rectifier Unit) have strongly challenged the capabilities of these equipment, marking critical axes of improvements as the need of higher temperature components, filters design, and noise. Taking into account these elements, the need of a complete redesign in all the aspects, is essential.

Consequently, the topology and the need of a control strategy (BCRU (Battery Charge and Rectifier Unit) vs. TRU), elements that have not been traditionally challenged, will be studied to achieve the required expectations.

Finally, high level of maturity has to be demonstrated to integrate this equipment in the next More Electrical Aircraft representative test bench.

2. Scope of work

SGO ITD is looking for a partner to design, manufacture and test a 10kW 230Vac-28Vdc converter unit, satisfying network quality requirements for both AC and DC sides.

The activities to be performed are

- Perform a detailed comparison between several transformer-rectifier and controlled rectifier designs. The objective is to determine the best option in terms of electrical performances (as ripple with or without voltage harmonic distortion at the input, inrush current, current harmonic distortion, voltage slop), noise and weight. The transformer-rectifier possible topologies will be analysed in this stage.
- Propose a design for a 10kW 230Vac-28Vdc converter, coherent with the study performed in the first task
- Manufacture and test a TRL5 10kW prototype

During study and design phase, the possibility of implementing high temperature components shall be taken into account, as another solution to solve thermal challenges.

After in-house testing, the applicant shall deliver one prototype of the AC-DC unit to be integrated in a test bench representative of the More Electrical Aircraft complete electrical network, so that further tests can be performed at level unit, and integration with AC network and 28Vdc network and batteries can also be evaluated.

3. Type of work

There will be 4 main tasks associated to a deliverable at the end of each task. They are:

Task 1 – Study of the possible topologies of controlled and non-controlled AC/DC converters

Task 2 – Design of the converter, taking into account the decisions derived from the Task 1.

Task 3 – Manufacturing of the prototype

Task 4 – Tests to validate the prototype's performances and capabilities.

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

Very good knowledge of aeronautics constraints (environment, qualification)

Very good background and experience in static converters design and manufacturing

The equipment of the partner should be adequate to perform the tasks (simulation, design, manufacturing, testing) in the required time.

5. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Study of TRU vs. BCRU		T0 + 6 Months
D2	Prototype final design		T0 + 12 Months
D3	Prototype		T0 + 18 Months
D4	Validation tests		T0 + 24 Months

6. Topic value (€)

The **maximum value** for this topic is

500,000 €

[Five Hundred Thousand Euro]

Clean Sky Joint Undertaking
SP1-JTI-CS-2013-01-SGO-04-008

Topic description

CfP Nbr	Title		
JTI-CS-2013-1-SGO-04-008	Electrical equipment modelling for test rig virtual integration	**End date**	T0+24 Months
		Start date	T0

1. Background

The Systems for Green Operations ITD of Clean Sky aims to demonstrate substantial performance and economic benefits of more electric aircraft technologies.

For electrical systems, comprehensive validation activities are mandatory to allow such a demonstration. Indeed, by correlating performances and design margins of both network and equipment, aircraft manufacturers ensure safe and reliable operation: any sub-system not complying with its specification requirements may lead the network exceeding its operating limits, further leading to improper operation and additional failures.

In Clean Sky SGO, definition and validation of the electrical network will be done in a complementary way by simulation studies and demonstration of equipment and network operation on a test rig. Prior to simulation activity, the development of an adequate simulation platform is required, including accurate and robust models library and advanced post processing tool.

In SGO WP4.2.5, several multi-domain powerful modelling frameworks are used to simulate the energy systems of the More Electrical Aircraft.

For the development of the electrical network simulation platform, SABER software is the reference. SABER software has demonstrated in previous aircraft programs and research project its suitability to fully support aircraft electrical network V&V process.

To benefit of latest features of SABER simulation tool (modelling language, library and simulation management, solver robustness and performances allowing to simulate more complexes systems, data post processing through advanced analysis tools and interface ergonomics), SABER RD version has been chosen.

2. Scope of work

In this framework, WP4.2.5 concentrates on the detailed modelling of the electrical system.

The Systems for Green Operations ITD is looking for a SABER RD modelling specialist to become a partner of the consortium taking part in virtual platform development by performing the following tasks:

- Development of accurate and robust SABER RD models according to equipment designs

- Development of post processing scripts/tools to assess electrical network performances from simulation results and rig measurements

The main tasks of this CfP applicant to develop the simulation platform will be to:

- Make the specification document defining the simulation model requirements its own and propose ways of improvement

- Develop SABER RD models according to electrical network equipment. Two different levels of details have to be implemented:

    - Functional models for large time frame analysis, such as power flow and network stability analysis,

    - Behavioural models for accurate power quality analyses.

Model development will have to be performed to ensure integration at network level and then requires integration validation. Models will be delivered at different degrees of maturity, from preliminary models at the beginning of the project, through consolidated models and finally validated models regarding accuracy and convergence aspects. Maturity will be increased from feedback from partner in charge of simulation activity and equipment providers. Input data for model development can be equipment description from analytical equations, sizing parameters, test measurements or existing models (SABER or another simulation software).

- Run single model stand-alone simulation to characterise simulated equipment performances

Develop post processing scripts & tools related to aircraft standards performances verification (network stability and power quality studies).

- Provide documentations related to models hypothesis and performances
- Provide documentation related to scripts developed
- Develop generic and tuneable electrical models (classical aeronautical electrical equipments) to allow quick electrical network benchmark integration making validation activity easier, and creating a high quality basis for specific model development. The typical architecture of the electric network consists of AC and DC generators, a power centre, AC/DC DC/DC and AC/AC converters and machine loads. To provide an indication of the amount of work around 10 models will have to be developed.

3. Type of work

The expected work will mainly consist in modelling activities of electrical equipment with adequate documentation (user guide, validation report) and post processing scripts.

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

Strong expertise in modelling process in the technological field and script development in SABER RD environment is requested.

The modelling activity will have to be performed with system level vision to ensure the robustness of the simulation platform. As a consequence, deep and proven experience in solver convergence issues management has to be demonstrated.

5. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Delivery of equipment models and related documentation	Model library and documentation	T0+ 6 Months T0+ 12 Months T0+ 18 Months
D2	Delivery of post processing tools	Script and tool library and documentation	T0+ 6 Months T0+ 12 Months T0+ 18 Months
D3	Delivery of generic models and related documentation	Model library and documentation	T0+ 24 Months
D4	Dissemination report	Short summary of the activity undertaken in the project for dissemination purpose	T0+ 30 Months

6. Topic value (€)

The **maximum value** for this topic is

500,000 €

[Five Hundred Thousand euro]

Clean Sky – Technology Evaluator

No topics for Technology Evaluator