European Commission
Research Directorates

Call for Proposals:

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

Call Text

Call Identifier

SP1-JTI-CS-2012-01 – A
Eco design
Green Regional Aircraft
Green Rotorcraft
Sustainable and Green Engines

See separate document for:
Smart Fixed Wing Aircraft
Systems for Green Operations

Index

Document change log

Specialised and technical assistance:

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

EPSS Help desk support@epss-fp7.org

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- Topic manager (not to be published)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: yyyyyyyyy

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

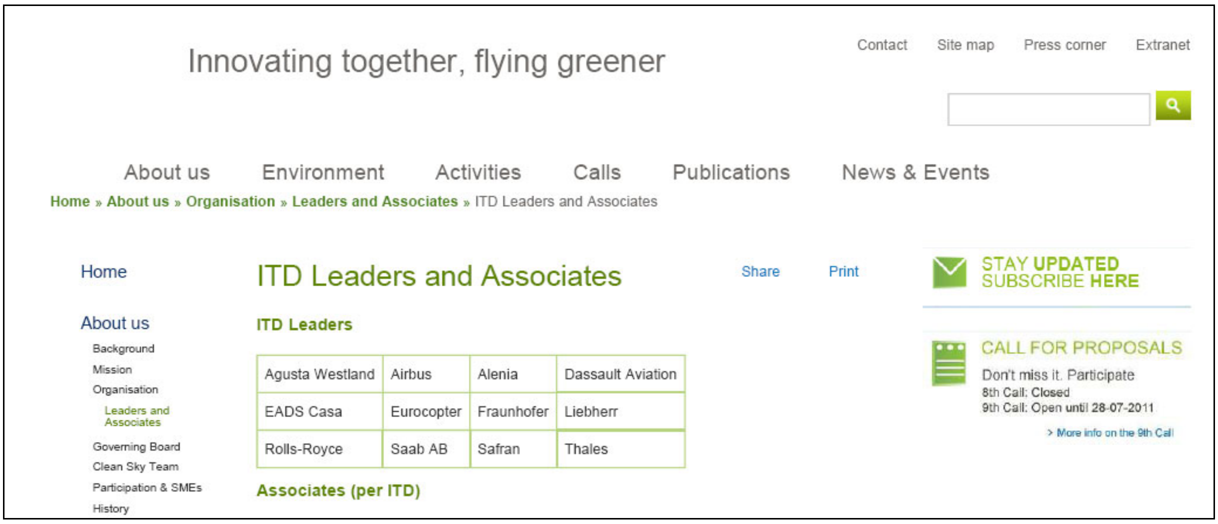
Make sure this total amount is below the value of the topic!!
Better, keep at least 5% margin.
Final amount is to be discussed in the negotiation.

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.

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



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: 13 January 2012**
- **Call close: 3 April 2012, 17:00**

- Evaluations (indicative): 21-25 May 2012

- Start of negotiations (indicative): 25 June 2012
- Final date for signature of GA by Partner: 31 July 2012
- Final date for signature of GA by Clean Sky JU: 10 August 2012

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-2012-01@cleansky.eu

Questions received until **9 March 2012** will be considered.

A first version of the Q/A document will be released by **17 February 2012**.

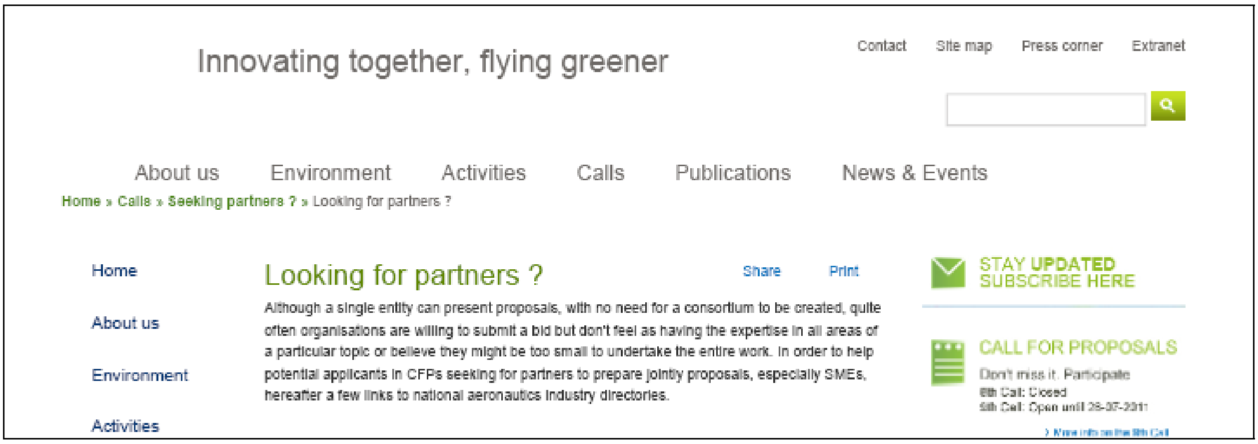
The final version of the Q/A document will be released by **18 March 2012**.

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.

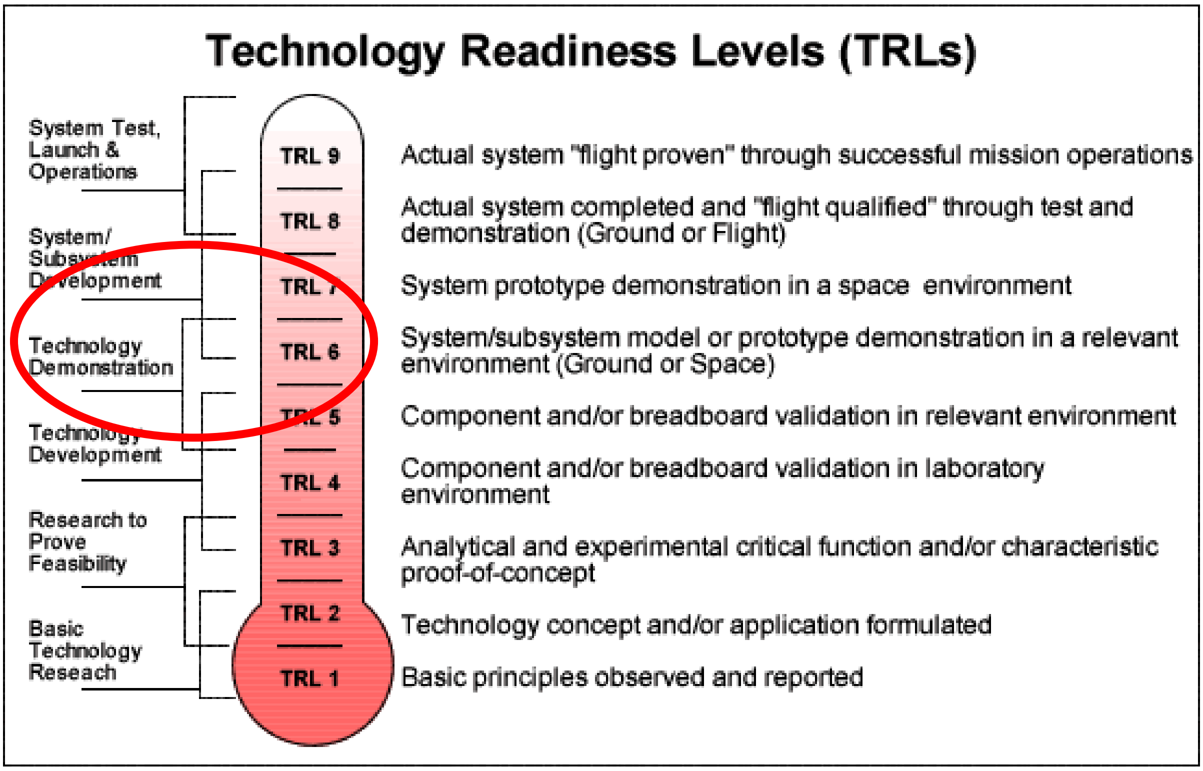
Looking for Partners?

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:



Clean Sky Joint Undertaking
Call SP1-JTI-CS-2012-01

European Commission
Research Directorates

Identification	ITD - AREA - TOPIC	topics	VALUE	MAX FUND
JTI-CS-ECO	**Clean Sky - EcoDesign**	**14**	**3,295,000**	**2,471,250**
JTI-CS-ECO-01	*Area-01 - EDA (Eco-Design for Airframe)*		**3,045,000**	
JTI-CS-2012-1-ECO-01-041	Autoclave cycle optimisation		100,000	
JTI-CS-2012-1-ECO-01-042	Technology Development for CFRP recovery/recycling		150,000	
JTI-CS-2012-1-ECO-01-043	Process Investigations for Liquid Resin Impregnation (LRI) and Out-of-autoclave (OoA) curing of composites		500,000	
JTI-CS-2012-1-ECO-01-044	Methodology Toolbox for Accelerated Fatigue Testing of Fiber Reinforced Laminates		200,000	
JTI-CS-2012-1-ECO-01-045	Process scale up for recovery and recycling of glass-fiber a/c insulation material in pilot scale		220,000	
JTI-CS-2012-1-ECO-01-046	End of life aircraft material identification and material ageing characterization by Raman Spectrometry		250,000	
JTI-CS-2012-1-ECO-01-047	End of life aircraft material identification and thermal damage characterization by Fourier Transform Infra Red		150,000	
JTI-CS-2012-1-ECO-01-048	End of life aircraft material identification by Laser-Induced Breakdown Spectroscopy		150,000	
JTI-CS-2012-1-ECO-01-049	Direct Manufacturing of stator vanes through electron beam melting		150,000	
JTI-CS-2012-1-ECO-01-050	Metal recycling: Recycling routes screening and design for environment		280,000	
JTI-CS-2012-1-ECO-01-051	Environmental friendly ancillary materials development		160,000	
JTI-CS-2012-1-ECO-01-052	Development of a fully automated preforming line for the production of 3-D shaped composite dry fiber profiles		300,000	
JTI-CS-2012-1-ECO-01-053	Disintegration of fibre-reinforced composites by electrodynamic fragmentation technique		435,000	
JTI-CS-ECO-02	*Area-02 - EDS (Eco-Design for Systems)*		**250,000**	
JTI-CS-2012-1-ECO-02-013	Electrical Test Bench Generic Configuration Behavourial Electrical Network Analysis Model		250,000	
JTI-CS-GRA	**Clean Sky - Green Regional Aircraft**	**11**	**9,960,000**	**7,470,000**
JTI-CS-GRA-01	*Area-01 - Low weight configurations*		**4,260,000**	
JTI-CS-2012-1-GRA-01-042	Advanced Floor Grids for Green Regional A/C. New concept of design, manufacturing and installation in Ground Full Scale Demo		2,200,000	
JTI-CS-2012-1-GRA-01-043	Smart Distributed Sensory Systems		260,000	
JTI-CS-2012-1-GRA-01-044	Design, development and realization of a novel micro-wave based curing device for out-of-autoclave carbon fiber reinforced composite		150,000	
JTI-CS-2012-1-GRA-01-045	Advanced Liquid Infusion Tecnology for regional wing structure: Numerical simulation and validation through an innovative test bench		330,000	
JTI-CS-2012-1-GRA-01-046	Collapsible Tooling Proposal for a/c nose fuselage & cockpit		300,000	
JTI-CS-2012-1-GRA-01-047	Advanced light pressure bulkhead for a/c cockpit		320,000	
JTI-CS-2012-1-GRA-01-048	Modelling and Simulation of a self sensing Curved composite panel to predict/control damage evolution in real load condition		400,000	
JTI-CS-2012-1-GRA-01-049	Optimal tooling system design for large composite parts		300,000	
JTI-CS-GRA-02	*Area-02 - Low noise configurations*		**4,300,000**	
JTI-CS-2012-1-GRA-02-019	Transonic NLF wing and LC&A integrated technologies: Experimental Validation by Innovative WT Tests		4,300,000	
JTI-CS-GRA-03	*Area-03 - All electric aircraft*		**1,400,000**	
JTI-CS-2012-1-GRA-03-009	Advanced Flight Control System – Design, development and manufacturing of EMA with associated ECU and dedicated test bench		1,100,000	
JTI-CS-2012-1-GRA-03-010	Control Consolle and Electrical Power Center per Flight Demo		300,000	
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**	**1,450,000**	**1,087,500**
JTI-CS-GRC-01	*Area-01 - Innovative Rotor Blades*		**400,000**	
JTI-CS-2012-1-GRC-01-008	Mould design and manufacture for the production of a very high tolerance model helicopter blade		400,000	
JTI-CS-GRC-02	*Area-02 - Reduced Drag of rotorcraft*			
JTI-CS-GRC-03	*Area-03 - Integration of innovative electrical systems*		**650,000**	
JTI-CS-2012-1-GRC-03-012	Development and delivery of EMA for a light helicopter		650,000	
JTI-CS-GRC-04	*Area-04 - Installation of diesel engines on light helicopters*			
JTI-CS-GRC-05	*Area-05 - Environmentally friendly flight paths*			
JTI-CS-GRC-06	*Area-06 - Eco Design for Rotorcraft*		**400,000**	
JTI-CS-2012-1-GRC-06-005	Recycling of Metallic Materials from Rotorcraft Transmissions		200,000	
JTI-CS-2012-1-GRC-06-006	Disassembly of eco-designed helicopter demonstrators		200,000	
JTI-CS-SAGE	**Clean Sky - Sustainable and Green Engines**	**11**	**16,150,000**	**12,112,500**
JTI-CS-SAGE-01	*Area-01 - Open Rotor Demo 1*			
JTI-CS-SAGE-02	*Area-02 - Open Rotor Demo 2*		**13,150,000**	
JTI-CS-2012-1-SAGE-02-011	Pitch Change Mechanism development, test and supply for engine demonstrator		7,000,000	
JTI-CS-2012-1-SAGE-02-012	Optimal High Lift Turbine Blade Aero-Mechanical Design		850,000	
JTI-CS-2012-1-SAGE-02-013	Advanced Non Destructive Testing methods and equipment development for fabricated structures.		500,000	
JTI-CS-2012-1-SAGE-02-014	Enhanced material and lifing model including sustained peak Low Cycle Fatigue		900,000	
JTI-CS-2012-1-SAGE-02-015	Advanced electrical machine manufacturing process implementation and tuning based on composite material process technologies		200,000	
JTI-CS-2012-1-SAGE-02-016	Study and durability of electrical insulating material in aircraft engine chemical environment		200,000	
JTI-CS-2012-1-SAGE-02-017	Variable thickness lamination machine-tool design and manufacturing		500,000	
JTI-CS-2012-1-SAGE-02-018	Engine Mounting System and Engine In-flight Balancing System		3,000,000	
JTI-CS-SAGE-03	*Area-03 - Large 3-shaft turbofan*		**2,600,000**	
JTI-CS-2012-1-SAGE-03-012	Non-metallic Pipes for Aero engine Dressings		1,800,000	
JTI-CS-2012-1-SAGE-03-013	Extended operation temperature range for compressor structure materials		800,000	
JTI-CS-SAGE-04	*Area-04 - Geared Turbofan*			
JTI-CS-SAGE-05	*Area-05 - Turboshaft*		**400,000**	
JTI-CS-2012-1-SAGE-05-016	Telemetric System Acquisition in harsh Environment		400,000	

Clean Sky – Eco Design

Identification	ITD - AREA - TOPIC	topics	VALUE	MAX FUND
JTI-CS-ECO	**Clean Sky - EcoDesign**	**14**	**3,295,000**	**2,471,250**
JTI-CS-ECO-01	*Area-01 - EDA (Eco-Design for Airframe)*		**3,045,000**	
JTI-CS-2012-1-ECO-01-041	Autoclave cycle optimisation		100,000	
JTI-CS-2012-1-ECO-01-042	Technology Development for CFRP recovery/recycling		150,000	
JTI-CS-2012-1-ECO-01-043	Process Investigations for Liquid Resin Impregnation (LRI) and Out-of-autoclave (OoA) curing of composites		500,000	
JTI-CS-2012-1-ECO-01-044	Methodology Toolbox for Accelerated Fatigue Testing of Fiber Reinforced Laminates		200,000	
JTI-CS-2012-1-ECO-01-045	Process scale up for recovery and recycling of glass-fiber a/c insulation material in pilot scale		220,000	
JTI-CS-2012-1-ECO-01-046	End of life aircraft material identification and material ageing characterization by Raman Spectrometry		250,000	
JTI-CS-2012-1-ECO-01-047	End of life aircraft material identifiication and thermal damage characterization by Fourier Transform Infra Red		150,000	
JTI-CS-2012-1-ECO-01-048	End of life aircraft material identifiication by Laser-Induced Breakdown Spectroscopy		150,000	
JTI-CS-2012-1-ECO-01-049	Direct Manufacturing of stator vanes through electron beam melting		150,000	
JTI-CS-2012-1-ECO-01-050	Metal recycling: Recycling routes screening and design for environment		280,000	
JTI-CS-2012-1-ECO-01-051	Environmental friendly ancillary materials development		160,000	
JTI-CS-2012-1-ECO-01-052	Development of a fully automated preforming line for the production of 3-D shaped composite dry fiber profiles		300,000	
JTI-CS-2012-1-ECO-01-053	Disintegration of fibre-reinforced composites by electrodynamic fragmentation technique		435,000	
JTI-CS-ECO-02	*Area-02 - EDS (Eco-Design for Systems)*		**250,000**	
JTI-CS-2012-1-ECO-02-013	Electrical Test Bench Generic Configuration Behavourial Electrical Network Analysis Model		250,000	

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-ECO-01-041	**Autoclave Cycle optimisation**	**End date**	*To + 15*
		Start date	*To*

1. Topic Description

Objective of the call is to develop an algorithm to obtain full infusion and reduction of duration of the autoclave cure cycle through the optimization of key parameters with main focus on infusion process of composite parts.

The algorithm shall be based on a so-called "auto learning" approach.

The auto learning approach is based on data collected performing the tool/part thermal survey where several thermocouples are placed in carefully selected points of new tool and part before cure of production parts.

In the auto learning approach, thermal parameters related to thermal mass of tool and convective heat exchange coefficient are estimated by correlating the time variation of tool/part points temperature with autoclave fluid temperature.

Then starting from these parameters it is possible to predict the evolution of part/tool points temperature for whichever autoclave fluid temperature evolution.

If the chemical and rheology model of the specific resin is available it is possible to predict also the contribution of heat generated by polymerisation reaction and viscosity curve. All these data can be used for prediction of resin flow through dry reinforcement and to develop an autoclave temperature/pressure cycle able to give full impregnation of dry preform before resin gelification.

According to the above the specific work to be performed for this call for proposal is the development of an algorithm that implements the above approach to the infusion process starting from definition of the rheology and kinetic model for the selected resin.

The algorithm will be developed through:

- The definition of constitutive equations able to model temperature, viscosity and polymerisation evolution to obtain movement of resin flow through the dry reinforcement.
- The preparation of a software code that implements the above equations. The software will be prepared using a standard programming language like Visual basic or other and will operate on a standard PC having suitable and user friendly interfaces (PC ref. characteristics: CPU: 1,5 GHz – RAM: 1 GB – Operative System: Windows).
- The demonstration of software using it on infusion fabrication tests that the Topic Manager Company and related partners are performing.

Note: the resin and dry preform necessary for the activities will be delivered by the Topic Manager Company.

In the following a proposed Work Breakdown Structure and tasks description of the activities to be performed:

WP	TITLE
WP1	**Model generation**
Task 1.1	Feasibility study and info collection on Auto learning approach
Task 1.2	Generation of kinetic and viscosity model for selected resin
Task 1.3	Constitutive equation definition and verification
WP2	**Software preparation and verification**
Task 2.1	Software code preparation
Task 2.2	Software verification on liquid resin infusion fabrication test
Task 2.3	Software refiniment and delivery

WP1

Task 1.1 A feasibility study including info collection on the autolearning approach will be performed. In this task the background, proprietary information from Topic Manager Company will also be shared with the selected Partner that starting from this point will identify the most feasible way to go.
Task 1.2 The resin and fiber to be used in the model will be defined. Then the kinetic and rheology model for the resin will be prepared through laboratory test: DMA,DSC etc.. The permeability (planar and through the thickness) for the relevant reinforcement will be also evaluated.
Task 1.3 Based on the Autolearning approach the constitutive equations for modeling heat transfer/generation and resin flow through reinforcement will be generated and verified.

WP2

Task 2.1 The software to allow calculation of temperaure and resin flow will be developed/adapted using the constitutive equation of above task.
Task 2.2 The prepared software will be verified using data collected in liquid resin infusion fabrication test run by Topic Manager Company and its partners.
Task 2.3 After validation on test, the Software will be refined and delivered to Topic Manager Company with suitable manuals and training.

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

The applicant shall have a proven know-how in heat exchange, flow in porous media, thermoset resin testing and modeling. It shall also have good capability in software code preparation with friendly user interface.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Modelling approach document	Definition of modelling approach	To + 1
D2	Kinetic and rheology model	Kinetic and rheology model of selected resin and permeability data of selected reinforcement	To + 3
D3	Constitutive equation document	Constitutive equation for modelling, temperature, heat and resin flow	To + 6
D4	Software version A	Software preparation on the base of constitutive equation	To + 9
D5	Software validation document	Software validation on data from infusion test	To + 12
D6	Software version B	Validated software will be delivered with manuals and training will be performed	To + 15

4. Topic value (€)

The total value of this work package shall not exceed: **€ 100.000** **[one hundred thousand euro]** Please note that VAT is not applicable in the frame of the CleanSky program.

5. Remarks

None

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-ECO-01-042	**Technology Development for CFRP Recovery/ Recycling**	End date	*To + 15*
		Start date	*To*

Special Clause

The text of this topic contains the basic information for the applicant to understand the need of the ITD Topic manager.
*However, more detailed data are available in a separate info package that can be provided on request to the interested applicant; due to the confidentiality content of this supplementary document, it is necessary to enter a Non Disclosure Agreement **(NDA)** with the Topic Manager Company.*
Therefore the applicant who is willing to receive this detailed info package is invited to write to the call mailbox confirming the request. He'll receive a NDA to sign in two originals and to send to the JU.
The NDA will be passed to the Topic Manager and, when signed, will be returned in one copy to the applicant together with the Specification document.
Questions concerning the confidential data delivered will be handled in a dedicated Q/A document, which will only be circulated to those applicants who have signed the Confidentiality Agreement.

1. Topic Description

The objective of the call is to develop a key process for recovery and recycling CFRP uncured scraps.

As a matter of fact the Topic Manager Company that is issuing this call for proposal has already developed a uncured CFRP scraps recycling process aimed to use, rather than waste, material scraped during lamination.

The process is therefore a background proprietary information owned by the above Company and covered by patent or application for patent in Italy, Europe, USA etc.

Property of background information and results of the work performed within this call for proposal will be handled according to the rules of the program. Any subject willing to access to the information produced by this activities shall sign a Non-Disclosure Agreement with the Topic Manager Company.

In the concerned process the uncured CFRP scrapes coming in any shape and dimension from cutting of excess during Unidirectional plies lamination are cut by a suitable device in small elements, after backing paper removal. These elements, in the following "CFRP chips", have defined dimensions: 8 mm transverse to fibre direction x 50 mm parallel to fibre dimension.

After cutting the CFRP chips must be distributed rather uniformly over a backup paper to obtain a raw uncured plate of about 500 mm x1000 mm to be used subsequently as raw material to produce light weight structural elements.

It is object of this call for proposal the **development of a distribution module**, to distribute uniformly the above chips according to the following requirements.

The distribution Module shall be able to receive CFRP rectangular chips from cutting stage that feed the chips in a quite constant rate

1) The Distribution module will random orients and distribute the chips over a plate covered by a suitable baking paper. Plate will have a dimension of 500 mm transverse to fibre direction and 1000 mm parallel to fibre direction

2) Distribution shall be such that:

a. CFRP aerial weight will be 1000 (+/-200) gr/sqmt

b. Fibre orientation will be quasi isotropic i.e. 0°: 33 (+/-5)%, +/-45:33 (+/-5)%, 90°:33 (+/-5)%

In addition this distribution module will be such not to contaminate or alter CFRP chips. Therefore only allowed contact materials will be used and any process that can heat or cool or wet the materials shall be reviewed before application.

Note: the Topic Manager Company will provide to the selected Partner the pre-preg material for the necessary testing.

A proposed Work Breakdown Structure and activities description are as follows:

WP	TITLE
WP1	**Trade-off Study**
Task 1.1	Feasibility study for distribution module
Task 1.2	Trade off different approaches
Task 1.3	Define parameters and key components of the selected process
Task 1.4	Define suitable method to measure Fiber areal weigh and fiber orientation distribution on the plate
WP2	**Design and Manufacturing**
Task 2.1	Detail design of distribution module
Task 2.2	Fabrication of distribution module
Task 2.3	Stand alone demo of distribution module
Task 2.4	Integration of Distribution module in the overall feeding, cutting, distribution system

WP1

Task 1.1 The objective of task 1.1 is to identify different methods/mechanism to implement chips distribution i.e. air stream, vibration etc. For each method the key parameters and components will be identified. In this task there will be also defined the geometrical constrains to fit in the overall system.

Task 1.2 The different methods/mechanism will be compared and the most suitable for implementation will be selected. This involve close interaction with the Topic Manager Company to check compatibility with the overall propietary system.

Task 1.3 In this task the parameters and key elements of selected approach will be completely defined.

Task 1.4 will be devoted to define suitable method to measure fiber areal weight and fiber orientation distribution in at least 20 zone of the resulting CFRP plate.

WP2

Task 2.1 will be devoted to the detailed design of distribution module

Task 2.2 will be devoted to the fabrication of a working distribution module

Task 2.3 will be devoted to demonstrate the distribution module in a stand alone way i.e. CFRP chips will be feeded already cut. To demonstrate the proper working the supplier shall measure in a suitable way the distribution of CFRP areal weight and fiber distribution.

Task 2.4 will be devoted to integrate the distribution system in the overall feeding, cutting, compaction system developed by the Topic Manager Company as back ground. The integration will require a module to be delivered to the Topic Manager Company where the integration activities shall be performed.

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

The applicant shall have a background in the development and realization of mechanical device for uniform distribution of chips in any other fields and or have a know how on specific technique useful for the above application.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Proposed approach document	Definition of possible approach	To + 1
D2	Trade-off document	Selection of most suitable approach and definition of key parameters/components	To + 2
D3	Distribution module	Detail design of distribution module	To + 5

	drawings		
D4	Distribution Module Prototype	Distribution module will be fabricated	To + 11
D5	Stand-alone distribution module demonstration report	Distribution module demonstrated and measurement of Fibre areal weigh and fibre orientation will be reported	To + 12
D6	Integrated distribution module demonstration report	Distribution module will be integrated in the Topic Manager Company Overall system and demonstrated	To + 15

4. Topic value (€)

The total value of this work package shall not exceed:

150,000 €

[one hundred fifty thousand euro]

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

5. Remarks

None

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-ECO-01-043	**Process Investigations for Liquid Resin Impregnation (LRI) and Out-of-autoclave (OoA) curing of composites for high temperature applications**	**End date**	*T0+18 Months*
		Start date	*T0*

1. Topic Description

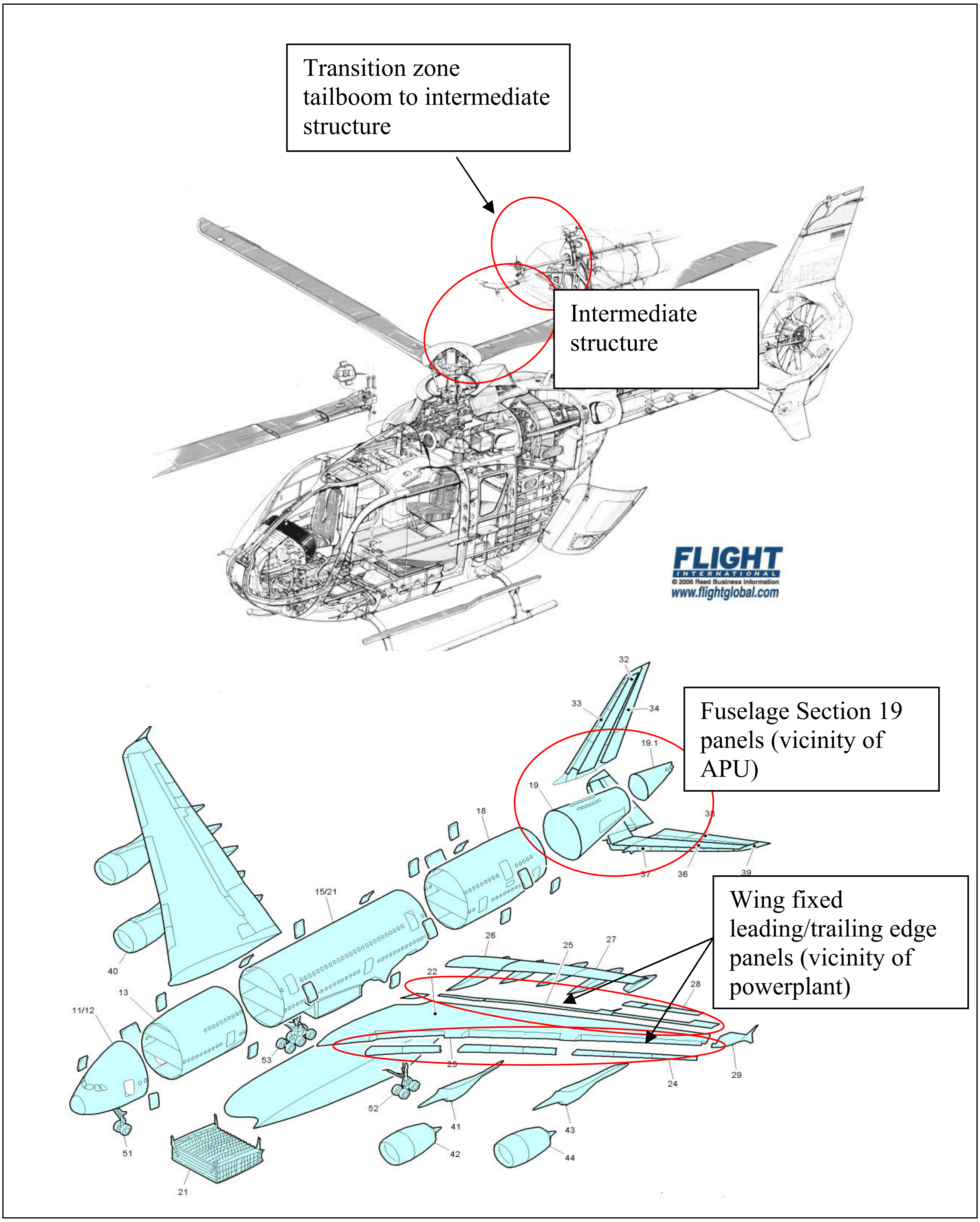
Certain aircraft and helicopter composite structures can experience high service temperatures in the range of 120°C to 250°C and are exposed to harsh environments in the outgas exhaust streams. Furthermore, the thermodynamic efficiency of modern day gas turbine engines can be improved by increasing the operating temperature of the gas stream. In effect, this requires development of composite materials with high temperature capabilities close to the powerplant and APU. The standard epoxy-based prepreg sytems do not fulfil the requirements and hence other solutions are sought. However, these are either heavy (metal shielding) or difficult to process (BMI prepreg). In addition, the current manufacturing solutions are based on prepreg hand lay-up followed by autoclave curing, which are time and energy consuming, and thus costly processes. One of the aims of CleanSky Eco-Design is to find and evaluate manufacturing technologies that lower the ecological footprint of such composite structures.

Recently, several composite materials systems have entered the market for high temperature applications based on new resin chemistries, such as benzoxazines and cyanate esters. In addition, more automated ways towards cost-efficient composites manufacturing are being developed, primarily based on liquid resin impregnation (LRI). These technologies incorporate closed processing and enables automation, as well as the reduction of ancillary materials (consumables). Overall cycle times can be reduced, leading to significant cost saving opportunities. When LRI is combined with an efficient curing technology that consumes less energy, this may lead to a very eco-efficient process chain, suitable for high temperature composites.

The aim of this call is therefore, to find new and innovative manufacturing solutions based on automatable closed technologies with out-of-autoclave curing, to reduce the ecological footprint of the manufacturing process for high temperature composite structures.

The following steps shall be performed by the applicant:

- Present several manufacturing concepts for a standardised set of representative parts taken from the high temperature prone parts, including the results of preliminary trials. Characteristic components include curved stiffened structures, such as a helicopter tail boom transition zone and intermediate sections (skin thickness in the range of 1-2mm and stiffeners 5-12mm), aircraft section 19 fuselage panels in the vicinity of the APU and aircraft wing leading/trailing edge panels in the vicinity of the powerplant, as indicated in the figures below.


Transition zone tailboom to intermediate structure
Intermediate structure
FLIGHT INTERNATIONAL
www.flightglobal.com
Fuselage Section 19 panels (vicinity of APU)
Wing fixed leading/trailing edge panels (vicinity of powerplant)

Evaluation of the presented concepts based on ecological requirements, as well as cost. One manufacturing solution will be selected and detailed.

- Selection of material systems, including resins, fibres, reinforcement types, based on the process requirements as well as technical requirements (a list with possible materials as well as technical requirements will be given at the beginning of the project by the topic manager).
- Manufacturing and testing of test coupons and sub-elements based on the selected manufacturing solution (parameter study). A test plan will be devised together with the topic manager.
- Definition of representative article to demonstrate the selected manufacturing technology together with topic manager. This step shall include definition of a quality assessment plan of the resulting article.
- Definition of manufacturing process for representative article, including preliminary trials and definition of in-line inspection methodologies.
- Manufacturing of representative article, including collection of data for life cycle assessment (the topic manager will provide guidelines for this)
- Evaluation of representative article according to the assessment plan and ecological requirements.

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

The applicant (single organization or a consortium) should have the following facilities and knowledges:

- Extensive experience and capabilities for automated manufacturing of thermoset composite components and experience in process optimisation (experience in LRI and OoA curing would be considered an advantage)
- Strong knowledge on thermoset resin based composites (knowledge on benzoxazine and cyanate ester resins would be an asset)
- Extensive experience and capabilities for in-line inspection and quality assessment of composite compenents
- Extensive experience and capabilities to relate the resin physical-chemical properties to the manufacturing process, i.e. characterizing cured and uncured resins properties (Tg, DSC, DMA, viscosity, …)
- Capabilities to manufacture and test material coupons, including hot/wet properties.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Manufacturing concepts	Presentation of three or more manufacturing concepts for representative family of parts	T0 + 3 months
D2	Materials selection		T0 + 3
D3	Manufacturing concept definition	Detailed presentation of selected manufacturing concept	T0 + 6
D4	Test report	Manufacturing and testing of coupons	T0 + 8
D5	Representative article definition		T0 + 9
D6	Manufacturing of representative article		T0 + 15
D7	Evaluation		T0 + 16
D8	Final report with collected LCA data		T0 + 18

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.

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)

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-ECO-01-044	**Methodology toolbox for accelerated fatigue testing of fiber reinforced laminates - micro-structural failure criterion**	**End date**	*To + 15*
		Start date	*To*

1. Topic Description

The use of fiber reinforced polymers (FRP) in structural parts contributes to the reduction of weight and, hence, of fuel consumption in future aircrafts. In order to probe the required level of structural safety, the fatigue life of FRP parts needs to be assessed in accelerated tests. One methodology is to determine the parameters of the time/temperature shift function by visco-elastic material characterization and to apply this superposition principle to the results of destructive constant strain rate and high frequency fatigue tests, which are performed at a limited number of load ratios and temperatures. Based on this data, a fatigue master curve is deduced that allows predicting the lifetime of FRP structures at arbitrary load ratios and temperatures. The methodology of accelerated lifetime prediction rests on the assumption of identical failure modes occurring under real service conditions as well as in all specimens of all tests performed. The methodology may result in misleading predictions in case of different failure modes.

Therefore, the **objective** of this call for proposal is

- to comprehensively validate the assumption of identical failure modes by in-depth analyses,
- to identify a criterion for quantifying the current level of fatigue damage and failure risk, and
- to determine threshold quantities for precise lifetime predictions based on the physics of the failure

The criterion and the threshold quantities shall cover arbitrary stack configurations of that type of multi-ply tape laminate, which will be provided by the partners of the Clean Sky ED-ITD. Moreover, it shall likewise hold for the various stress tests performed to assess the long-term fatigue behavior of aircraft structures, including multi-axial tests, as well as for the complex mechanical loading situation under real service conditions. Therefore, proposals responding to this call shall offer a *methodology toolbox* with the following **technical achievements**:

- Specification, design, and performance of accelerated tests determining the fatigue life of FRP structures with different ply stacks under load situations such as, for example but not limited to, bending, tension, and combined sets of those loads at various temperatures, strain rates, cyclic frequencies and load ratios.
- Prove of identical failure modes among those FRP specimen based on micro-structural evidence. Destructive and non-destructive techniques shall provide thorough information on the micro-structure of the specimens and the changes in at any stage of the tests. This way, the identity in the failure mode and their common characteristics shall be found. The local deformations shall in-situ be measured during the test by contact-free techniques such as by optical or X-ray techniques involving digital image correlation. Besides the 2-D and 3-D strain distribution, location and propagation of any crack front shall be determined.
- Identification of quantitative mechanical criterion that allows objective assessments on the fatigue status of the particular FRP structure. It shall be valid to all possible stack configurations, loads from arbitrary direction (in plane, normal, mixed mode) at any temperature and moisture level. This criterion shall be a force, a strain, an energy, or a combined fracture mechanics parameter, whose magnitude is determined, for example, by detailed numerical modeling and simulation of both, the global loading as well as the local micro-structural situations, in the FRP test specimens. Thresholds shall be determined characterizing onset and propagation speed, respectively, of the micro-structural damage leading to the failure of the structure.

Milestones

- Micro-structural identity of the failure mode is demonstrated for a multitude of FRP structures with minimum 3 different stack configurations under minimum 3 different load situations
- Failure criterion is identified allowing quantitative assessments in all situations of the failure mode and thresholds for onset and propagation speed of the micro-structural damage are quantified

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

- The applicant/consortium should have a strong background in mechanics and characterization of composite materials.
- The applicant/consortium must have a rich experience in numerical simulations of advanced materials, nonlinear finite element analyses, fracture mechanics and damage mechanics.
- The applicant/consortium must have all means in hand to satisfy the abovementioned requirements. Specifically, the applicant/consortium must have:
  - a material characterization lab with sample preparation workshop, universal and DMA testing equipment for all test modes mentioned in the task description featuring temperature chambers (-55°C to 200°C) providing for moisture control (up to 85%r.h.) and in-situ optical inspection
  - a lab for comprehensive physical failure and material analyses (complete set of materialographic tools and microscopes: e.g., optical, ultrasonic, X-Ray, SEM with EDX etc.) and for non-destructive techniques
  - tools and methods for in-situ contact-less multi-axial strain measurement by digital image correlation
  - all hardware and software tools for 3-D numerical simulation by techniques including FEM and X-FEM that allow automatic process control based on the full set of statistical and stochastic routines (for parameter identification, sensitivity analysis, robustness analysis, optimization etc.)

3. Major deliverables and schedule

Del. Ref. Nr.	Title	Description (if applicable)	Due date
D01	Feasibility Report	Demonstration of the feasibility of the tests, the physical analysis, and the numerical simulation for assessing the fatigue life on material samples provided by the partners within CS ED ITD	T0+6 month
D02	Research Report: Failure mode	The micro-structural identity of the failure mode is demonstrated for a multitude of different load situations in multi-ply FRP structures; the common characteristic of these load situations is clearly explained.	T0+12 months
D03	Final Report	An objective mechanical criterion for quantifying the micro-structural damage leading to the failure mode as shown in D02 is found and threshold values are determined	T0+15 months

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.

5. Remarks

None

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-ECO-01-045	**Process scale up for recovery and recycling of glass-fiber a/c insulation material in pilot scale**	**End date**	*To+20*
		Start date	*To*

1. Topic Description

Insulation material is applied in aircraft (a/c) structures mainly to provide for thermal insulation. During the use phase, it undergoes physical (thermal, mechanical) stresses. Amongst others, condensate accumulation in the insulation layer may contribute remarkably to the weight of aged a/c.

The goal of this CfP is to identify and to test the real-life recycling options of the insulation system (polymer bags plus insulation fibers) including a detailed description of the recycling process as well as production of recycling samples from a/c insulation materials. The primary focus is laid on the mineral portion of the insulation layer.

The following steps and research areas have to be adressed:

-Quanfication of insulation material mass in end of life a/c (airliners, business jets, rotorcrafts) and description of their end of life quality/properties including fiber length, moisture, assessment of the hazardousness of the insulation and bag material

-Identification and description of general recycling options for the insulation and bag material

-Acquisition of a/c insulation material samples for analytical tests and processing trials

-Treatment (e. g. sorting, mechanical, thermal treatment) of the insulation material in order to recycle the materials at the highest materials properties and value retained possible. The recycling experiments (hand-on trials) are expected to cover primary recycling and secondary recycling options:

Primary recycling is expected to cover at minimum polymer (bag) materials recycling into samplesto measure the mechanical properties and to identify other important properties such as e.g. flame retardancy, and fiber recovery for reinforcement purposes in polymer or other matrix materials . A minimum of five materials samples from polymers is to be produced and tested under this scheme. Secondary recycling is expected to cover at minimum thermal treatment of fibers in order to generate materials for building purposes. A minimum of three samples for different purposes (building applications) is expected to be produced. The products or fields of application in the building sector will have to be identified and described in detail. Samples from all trials including defined intermediate products along with the initial material samples will have to be handed over to the CS EDA consortium for free. It is expected that at minimum one final product made from polymers and three final fiber-based products will be made available to the consortium.

-Data for life cycle assessment will have to be handed over to the CS EDA consortium, in order to implement a LCA insulation recycling module into the LCA method. The scope and format of the data will be defined by the CS EDA consortium, and is expected to use the ELCD format.

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

The applying body or consortium is expected to have a proven track record in hands-on processing and recycling of fibrous insulation materials, especially for hazardous glass and mineral wool materials. Business operations in this field are highly appreciated. Moreover, access to or operation of chemical/analytical equipment for qualification of the initial material is necessary. The same applies to polymer processing and testing facilities (extrusion, injection moulding, testing facilities for materials properties, fiber length measurement).

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Kick-off meeting	final agreement on work plan, contents, and time planning	T0+ 2 Months
D2	Insulation samples and testing plan	Insulation samples are available for testing in sufficient mass, testing plan is ready for execution, testing plan is agreed	T0 + 6 Months

		upon with CS EDA Consortium	
D3	Overview report	Report covering identification and description of general recycling options for the insulation and bag material	T0 + 8 Months
D4	Intermediate recycling and testing report on practical trials	Meeting incl. Presentation and Minutes on practical trials progress, testing plan update, intermediate LCA data will be handed over to CS EDA	T0 + 12 Months
D5	Product Samples assessment	Presentation and handover of product samples, presentation of recycling facility (possibly on-site), assessment of product quality, testing schedule update	T0 + 16 Months
D6	Final Report	providing detailed information on all CfP activities, especially on the practical recycling steps, results, products quality, Life cycle assessment data	T0 + 20 Months

4. Topic value (€)

The total value of this work package shall not exceed:

€ 220 000

[two hundred twenty thousand euro]

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

5. Remarks

None

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-ECO-01-046	**End of life aircraft material identification and material ageing characterization by Raman Spectrometry. Proof of concept of Raman-based method for industrial use in recycling industry.**	**End date**	*T0+18*
		Start date	*T0*

1. Topic Description

Aircraft at the end of their service life will be recycled in future. In Europe, it is fast becoming common practice to dismantle old aircraft and recycle most of the metals. Recycling works best if the metals are segregated by alloy. It is already possible to identify alloys using portable equipment; this technique is reliable and fast. An aircraft is not only made of metal parts. There are also a lot of organic parts in different forms like raw plastics, foams, carbon/glass fibre reinforced plastics (C/GFRP), etc. The objective of this call is to achieve the same sorting for polymers as metal parts.

Shape requirements:

The final aim of this device is to be used in aircraft dismantling workshop. Thus, ideally the device should be handheld for a fast and an easy of use concerns. Nevertheless if a transportable device offers significant advantage compare to a handheld one it could be envisaged to cut a piece of material for identification.

Performance requirements:

1)Identification: As a minimum, the identification method should be able to distinguish between the thermoset- and thermoplastic resins commonly used in airframes: epoxy + carbon fibre; PEEK, PPS, PEKK + carbon fibre. If the individual polymers can also be identified, this can be of use as well.

2)In depth study: If distinguishing or identification can be achieved “looking through” a coating system of up to 0.2 mm, this will be a great advantage. Characterisation of polymers at even greater depths can also be useful.

3)Ageing: If the “state of ageing” of the polymers can be detected, this can also be a considerable bonus, in light of possible re-use.

The aim of this CfP is to find partners to optimize and/or to develop a commercialized Raman spectrometer which will fulfil our requirements. The first requirement, the most important one, named: “Identification” has to be met. Meeting requirement 2 (In-depth study) and/or requirement 3 (Ageing) is desirable.

Testing shall follow the three steps hereafter:

-Identify thermoset and thermoplastic resins of specimens provided by the topic manager (5 samples). As Raman technology is a quantitative method, it could be interesting, for an environmental point of view, to quantify substances affected by REACH.

-Identify material resin without removing the protecting surfaces (in-depth study). Material identification through a coating system will allow us a faster identification due to the fact that sanding with abrasive paper would not be necessary anymore. The surface protection of composite parts is made of 4 layers: Pre-treatment + Primer + Top coat + Finish paint. Material used for these layers and thickness vary according to environmental condition of the material part. Several coupons with different surface protections will be provided. Moreover to see the effect of the lightning strike protection on Raman spectrum, samples with and without bronze mesh will be provided.
-Make correlation between material ageing and Raman spectrum. Three material degradations have been selected for the study: thermal damages, effect of a solvent and stress. Various states of ageing will be provided by the topic manager: several levels of ageing state per degradation.

Trial tests shall include the study of material with several spectrometers. It will allow to compare results from spectrometers with more or less resolution, therefore to determine the necessary level of resolution for the three points of the study.
Moreover, the requirement concerning device shape should not exclude trials with non transportable spectrometers.
Finally, partner shall deliver a specification for helping equipment manufacturer to develop improved apparatus in future.

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

The following skills and equipments are required:
-Rich experience in Raman spectroscopy and material sciences
-(Trans-)portable Raman spectrometers

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Feasibility study using a set of coupons that will be provided (thermosets and thermoplastics; coated or not; various states of ageing)	Report	T0+12
D2	(Trans-)portable device: if needed, development of a first portable or at least transportable device in preparation of next step	Demonstrator	T0+15
D3	Identification method: improvement of device if needed. Development of method for using it effectively on real retired aircraft components. Access will be given to the Ageing Aircraft facilities of Topic Manager, containing a collection of retired aircraft components.	Report	T0+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.

5. Remarks

None

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-ECO-01-047	**End of life aircraft material identification and thermal damage characterization by Fourier Transform Infra Red. Proof of concept of FT IR-based method for industrial use in recycling industry.**	**End date**	*To + 18*
		Start date	*To*

1. Topic Description

Aircraft at the end of their service life will be recycled in future. In Europe, it is fast becoming common practice to dismantle old aircraft and recycle most of the metals. Recycling works best if the metals are segregated by alloy. It is already possible to identify alloys using portable equipment; this technique is reliable and fast. An aircraft is not only made of metal parts. There are also a lot of organic parts in different forms like raw plastics, foams, carbon/glass fibre reinforced plastics (C/GFRP), etc. Therefore the objective of this call is to achieve the same sorting for polymers as metal parts.

Shape requirements:

The final aim of this device is to be used in aircraft dismantling workshop. Thus, ideally the device should be handheld for a fast and an easy of use concerns. Nevertheless if a transportable device offers significant advantage compare to a handheld one it could be envisaged to cut a piece of material for identification.

Performance requirements:

1) Identification: As a minimum, the identification method should be able to distinguish between the thermoset- and thermoplastic resins commonly used in airframes: epoxy + carbon fibre; PEEK, PPS, PEKK + carbon fibre. If the individual polymers can also be identified, this can be of use as well.
2) In-depth study: If distinguishing or identification can be achieved "looking through" a coating system of up to 0.2 mm, this will be a great advantage. Characterisation of polymers at even greater depths can also be useful.
3) Ageing: If the "state of ageing" of the polymers can be detected, this can also be a considerable bonus, in light of possible re-use.

The aim of this CfP is to find partners to optimize and/or to develop a commercialized FTIR spectrometer which will fulfil our requirements. The first requirement, the most important one, named: "Identification" has to be met. Meeting requirement 2 (In-depth study) and/or requirement 3 (Ageing) is desirable.

Testing shall follow the three steps hereafter:

- Identify thermoset and thermoplastic resins of specimens provided by the topic manager (5 samples). As FT-IR technology is a quantitative method, it could be interesting, for an environmental point of view, to quantify substances affected by REACH.
- Identify material resin without removing the protecting surfaces (in-depth study). Material identification through a coating system will allow us a faster identification due to the fact that sanding with abrasive paper would not be necessary anymore. The surface protection of composite parts is made of 4 layers: Pre-treatment + Primer + Top coat + Finish paint. Material used for these layers and thickness vary according to environmental condition of the material part. Several coupons with different surface protections will be provided. Moreover to see the effect of the lightning strike protection on FTIR spectrum, samples with and without bronze mesh will be provided.

- Make correlation between material ageing and FT-IR spectrum. Three material degradations have been selected for the study: thermal damages, effect of a solvent and stress. Various states of ageing will be provided by the topic manager: several levels of ageing state per degradation.

Trial tests shall include the study of material with several spectrometers. It will allow us to compare results from spectrometers with more or less resolution, therefore to determine the necessary level of resolution for the three points of the study.
Moreover, the requirement concerning device shape should not exclude trials with non transportable spectrometers.

Finally, partner shall deliver a specification for helping equipment manufacturer to develop improved apparatus in future.

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

The following skills and equipments are required:
- Rich experience in FTIR spectroscopy
- Portable FTIR spectrometer

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Feasibility study using a set of coupons that will be provided (thermosets and thermoplastics; coated or not; various states of ageing)	Report	T0+12
D2	(Trans-)portable device: if needed, development of a first portable or at least transportable device in preparation of next step	Demonstrator	T0+15
D3	Identification method: improvement of device if needed. Development of method for using it effectively on real retired aircraft components. Access will be given to the Ageing Aircraft facilities of Topic Manager, containing a collection of retired aircraft components.	Report	T0+18

4. Topic value (€)

The total value of this work package shall not exceed:

€ 150.000

[one hundred fifty thousand euro]

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

5. Remarks

None

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-ECO-01-048	**End of life aircraft material identification by Laser-Induced Breakdown Spectroscopy. Proof of concept of LIBS-based method for industrial use in recycling industry.**	**End date**	*To + 18*
		Start date	*To*

1. Topic Description

Aircraft at the end of their service life will be recycled in future. In Europe, it is fast becoming common practice to dismantle old aircraft and recycle most of the metals. Recycling works best if the metals are segregated by alloy. It is already possible to identify alloys using portable equipment; this technique is reliable and fast. An aircraft is not only made of metal parts. There are also a lot of organic parts in different forms like raw plastics, foams, carbon/glass fibre reinforced plastics (C/GFRP), etc. Therefore the objective of this call is to achieve the same sorting for polymers as metal parts. A LIBS detects elements of material, so it is useful for metal parts and organic parts as well, it would be possible to have only one device on aircraft dismantling workshop to identify materials.

Shape requirements:

The final aim of this device is to be used in aircraft dismantling workshop. Thus, ideally the device should be handheld for a fast and an easy of use concerns. Nevertheless if a transportable device offers significant advantage compare to a handheld one it could be envisaged to cut a piece of material for identification.

Performance requirements:

4) Identification: As a minimum, the identification method should be able to distinguish between the thermoset- and thermoplastic resins commonly used in airframes: epoxy + carbon fibre; PEEK, PPS, PEKK + carbon fibre. If the individual polymers can also be identified, this can be of use as well.

5) In-depth study: If distinguishing or identification can be achieved “looking through” a coating system of up to 0.2 mm, this will be a great advantage. Characterisation of polymers at even greater depths can also be useful.

6) Ageing: If the “state of ageing” of the polymers can be detected, this can also be a considerable bonus, in light of possible re-use.

The aim of this CfP is to find partners to optimize and/or to develop a commercialized LIB spectrometer which will fulfil our requirements. The first requirement, the most important one, named: “Identification” has to be met. Meeting requirement 2 (In-depth study) and/or requirement 3 (Ageing) is desirable.

Testing shall follow the three steps hereafter:

- Identify thermoset and thermoplastic resins of specimens provided by the topic manager (5 samples). As LIBS technology is a quantitative method, it could be interesting, for an environmental point of view, to quantify substances affected by REACH.

- Identify material resin without removing the protecting surfaces (in-depth study). Material identification through a coating system will allow us a faster identification due to the fact that sanding with abrasive paper would not be necessary anymore. The surface protection of composite parts is made of 4 layers: Pre-treatment + Primer + Top coat + Finish paint. Material used for these layers and thickness vary according to environmental condition of the material part. Several coupons with different surface protections will be provided. Moreover to see the effect of the lightning strike protection on LIBS spectrum, samples with and without bronze mesh will be provided.

- Make correlation between material ageing and LIBS spectrum. Three material degradations have been selected for the study: thermal damages, effect of a solvent and stress. Various states of ageing will be provided by the topic manager: several levels of ageing state per degradation.

Trial tests shall include the study of material with several spectrometers. It will allow to compare results from spectrometers with more or less resolution, therefore to determine the necessary level of resolution for the three points of the study.
Moreover, the requirement concerning device shape should not exclude trials with non transportable spectrometers.

Finally, partner shall deliver a specification for helping equipment manufacturer to develop improved apparatus in future.

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

The following skills and equipments are required:
- Rich experience in Laser Induced Breakdown Spectroscopy
- (Trans-)portable Laser Induced Breakdown spectrometer

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Feasibility study using a set of coupons that will be provided (several metal alloys; thermosets and thermoplastics; coated or not; various states of ageing)	Report	T0+12
D2	(Trans-)portable device: if needed, development of a first portable or at least transportable device in preparation of next step	Demonstrator	T0+15
D3	Identification method: improvement of device if needed. Development of method for using it effectively on real retired aircraft components. Access will be given to the Ageing Aircraft facilities of Topic Manager, containing a collection of retired aircraft components.	Report	T0+18

4. Topic value (€)

The total value of this work package shall not exceed:

€ 150,000

[one hundred fifty thousand euro]

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

5. Remarks

None

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-ECO-01-049	**Direct Manufacturing of stator vanes through electron beam melting**	**End date**	To +12
		Start date	*To*

1. Topic Description

New aeronautical engine designs strive the manufacturers to use new shaping processes which permit to add specific features such as stiffeners, often leading to weight or lead time saving. Electron beam melting (EBM) process is identified to as potential candidates but is not yet fully understood and controlled because of its lack of maturity. One important advantage of this process is that the powder particles not affected by the heat source can be recycled for further fabrications, meaning that only the quantity of material required to build up the parts is used in contrast to machining where up to 80% of material is removed away (reducing the buy to fly ratio). So far, no specific criteria exist in terms powder recyclability such as the number of manufacturing, the storage atmosphere, etc. Obviously, these criteria are primordial to reduce the raw material consumption while guarantying mechanical properties as high as fresh powder.

Based on this context, this project is aimed at investigating the mechanical properties of aeronautical Ti6Al4V stator vanes elaborated by Electron Beam Melting. These stator vanes will be compared, in terms of geometry, surface roughness and mechanical properties, to the stator vanes manufactured in the WP2.2 by selective laser melting. This is particularly interesting because it is known that EBM has higher building rate than SLM. Then, cylindrical mechanical specimens (tensile and fatigue) will be manufactured with, in one side fresh powder and in the other side recycled powder, in order to assess the mechanical properties of Ti6Al4V material elaborated by EBM. Finally, this task will enable to determine the limit of use of the Ti6Al4V atomised powder associated with the EBM process, and therefore reduce as much as possible the raw material consumption to produce aeronautical components.

The requested activities addressed to the applicants are as follows:

- The first step of this work consists of optimising the process parameters of the Electron Beam Machine by producing metallurgical samples (cubes or bars or flat samples) with the correct metallurgical criteria as well as the correct microstructure. The applicant has to vary the process parameters until the aeronautical requirements are found (porosity level, grain size, microstructure, surface roughness).

- Once the applicant determines the process parameters which guarantee the aeronautical requirements, it must manufacture mechanical specimens in 2 building directions. These specimens will be metallurgically and mechanically characterised by Topic Manager.

- The remaining powder will also be analysed in order to verify its chemical composition, particle sizes etc...

- Other specimens will also be manufactured in 2 building directions but in this time they will have to be hot isostatic pressed in order to reduce the porosity level. These specimens will be metallurgically and mechanically characterised by Topic Manager.

- The next step of this work is to recycle the powder not affected by the electron beam, to determine the maximum level of use without affecting the mechanical properties, and finally to manufacture mechanical specimens which will be used to determine the mechanical properties.

- The final task of the project is to manufacture EBM stator vanes and mechanical specimens with fresh and recycled powder with low level of manufacturing defects and high dimensional accuracy in order to evaluate both the process and the resulting mechanical properties.

The innovative aspect of this project is to use a new manufacturing process which is able to sensitively reduce the buy to fly ratio of the material (process near net shape) but also to recycle the powder in order to use it as its maximum capability. Furthermore, because the process is much faster than the Selective Laser Melting technique, it implies a significant energy saving because it takes about half the time to manufacture guide vanes by EBM in comparison to SLM.

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

The following skills and equipments are required: An Electron Beam melting (EBM) machine capable of manufacturing Ti-6Al-4V material under vaccum. -The porosity content of the parts must be below 0.5 vol. % with defects below 300µm in size. The specimens must not show presence of cracking or distortion. -The applicants must be able to carry out hot isostatic pressure on the parts. -The applicants must have some notions of the metallurgical aspects of the alloy and parts as well as an engineering background.

3. Major deliverables and schedule

4. Deliverable	Title	Description (if applicable)	Due date
D1	EBM process parameters optimisation	Fabrication report + metallographic observations + description of the process parameters kept	To + 8 weeks
D2	Fabrication of 30 specimens without HIP by EBM	Fabrication report + specimens + 200g of recycled powder before and 200g of recycled powder after fabrication	To + 16 weeks
D3	Fabrication of 30 specimens with HIP by EBM	Fabrication report + specimens + 200g of recycled powder before and 200g of recycled powder after fabrication	To + 24 weeks
D4	Determination of the maximum level of the powder recyclability in terms of chemical composition and particle sizes. Make to sample to verify the microstructure	Fabrication report + powder analyses report	To + 32 weeks
D5	Fabrication of 30 specimens with by EBM but with recycled powder	Fabrication report + specimens + 200g of recycled powder before and 200g of recycled powder after fabrication	To + 40 weeks
D6	Fabrication of 20 stator vanes with HIP by EBM	Fabrication report + specimens + 200g of recycled powder before and 200g of recycled powder after fabrication	To + 48 weeks
D7	End report	Report resuming all fabrications	To + 52 weeks

5. Topic value (€)

The total value of this work package shall not exceed: **€ 150.000** **[one hundred fifty thousand euro]** Please note that VAT is not applicable in the frame of the CleanSky program.

6. Remarks

None

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-ECO-01-050	**Metal recycling : Recycling routes screening and Design for Environment**	**End date**	*T0 + 20 Months*
		Start date	*T0*

1. Topic Description

As of today, metals and composites form the most relevant materials share of a/c in operation. These are mainly aluminium alloys as well as carbon and glass fibre reinforced polymers. If dismantled properly, kept and processed separately as shown in the PAMELA project, metals recycling into the initial quality proves feasible. Nevertheless no information or technology is available to recover high grade alloys from these scrap materials. Thus the goal of this CfP is to develop a concept for the real-life recycling of a/c materials and to demonstrate it.

A method to identify a/c parts containing valuable materials should be developed by performing trials with different spectroscopy methods for metal and plastics identification. Furthermore scoping for applicable technologies for recovering and recycling of these materials should be carried out. Necessary preconditioning steps (e. g. mechanical treatment, etc.) should be described. This topic addresses TA 241-05-metals recycling and will support the development of eco design guidelines in WP 33 through pointing out difficulties and accentuating conclusions for detailed Design for Environment steps (e. g. process optimization, materials substitution).

Current dismantling and recycling processes based on real a/c parts have to be described in detail and carried out in practical trials. The applicant is expected to describe and apply the current dismantling technologies for a/c, and to identify and measure the quality of dismantled parts and metals. Moreover, dismantling guideline information in a combined written/photographic format is expected along with samples from dismantling in order to compare the quality of scrap from different sources (e. g. fuselage, wing, empennage).

Regarding metals recycling, the expected outcome is an overview over all a/c alloys along with hands-on samples, giving specific information on each alloy amongst other on:

-scrap quality requirements (e.g. removal of coatings, sealants)

-pre-treatment processes required/recommended/available

-processes and processors capable of recycling metals into standard alloys

-comment on batch size relevance (separate processing) in case a/c alloys are not fed into standard metals conversion processes.

It is expected that the applicant provides demonstrators (parts) and use selected of these processes in order to generate samples for the subsequent recycling and Design for Environment concept development.

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

The applying body or consortium is expected to have a track record in hands-on dismantling of large complex products such as e. g. cars, railcars, or possibly a/c, and in development of or contribution to recycling guidelines. Additional it is expected that the applicant has experiences in Design for Environment solutions for one or more of above listed complex products.

Moreover, in-depth practical and theoretical experiences in mechanical treatment of waste streams including sorting and grinding has to be available with the applicant.

Demonstrators from a/c applications should be provided by the applicant as well as identification technologies for metals and plastics.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Intermediate Synthesis Report	Report to describe in detail the state of the art including stakeholders, covering dismantling, design	T0 + 10 Months

		guidelines, processing, metallurgy , including updated work plan for remaining CfP project period	
D2	Dismantling – Report and samples	Report on the dismantling and identification trials including samples (a/c parts) from dismantling, with metals as well as plastics and reporting on potential recycling routes identified	T0 + 20 Months
D3	Report and presentation/workshop: Design for Recycling	Workshop with WP24 and WP33 participants to present and discuss intermediate results on recycling, and on aspects of design for recycling	T0 + 16 Months
D4	Processing– Report and samples	Report on the processing trials including samples (a/c parts) and their composition and potential identification and recycling routes identified	T0 + 20 Months
D5	Metallurgy– Report and samples	Report on the metallurgical trials including sample materials (alloys) and potential field of application in a/c or other application identified	T0 + 20 Months

4. Topic value (€)

The total value of this work package shall not exceed:

280,000 €

[two hundred eighty thousand euro]

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

5. Remarks

None

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-ECO-01-051	**Environmental friendly ancillary materials development**	**Start date**	*T0*
		End date	*T0+24*

1. Topic Description

The manufacturing of composite structure component is using huge volume of ancillary materials (peel ply, release film, breather, vacuum bag, sealant tape, injection tubes, adhesive tapes...). The ancillary materials are involved in all steps of the manufacturing process: lay-up, compaction final bagging for curing, preforming/hot forming... and in all kind of conditions from room temperature up to 200°C with vacuum and pressure. The ancillary materials are made of chemical polymer in film or fabrics (woven or non-woven). In most cases, all these materials are used one time and the pollution by the resin during the manufacturing process made them not suitable for recycling.

Innovative materials or bagging solution is of great interest for Clean Sky by aiming at :

- reducing the volume of waste.
- having more recyclable or biodegradable materials.

The call for proposal objectives are:

- to develop and adapt the use of innovative materials and polymer in the manufacturing of aeronautic structure components,
- to integrate functions on the material to reduce the number of different materials used,
- to improve the use of reusable materials.

The materials shall be suitable for carbon fibres reinforced epoxy resin structural parts manufactured in autoclave or liquid resin process.

The proposed solution have to be in accordance with one or more of the following objectives:

- Use of bio-polymer, bio-sourced materials
- Be recyclable or made with recycled materials,
- Reusable several times to reduce the waste volume
- Be with integrated functions to reduce the volume of waste, number of layer, and number of different polymer.
- Without VOC.
- Be innovative with new materials or bagging concept.

New product and solution shall be mature enough for implementation on demonstrator at the end of the project. The dimensions shall be suitable for part over 2.5m * 2.5m size. The proposal could be either innovative materials or bagging concept. The solution can be applicable to one step or more in the manufacturing process.

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

Skills required:

- Experience in composite manufacturing
- Experience in polymer materials, polymer films, fabrics (all types).

Equipment:

- All type of equipment used in the composite manufacturing is recommended.
- Equipment for film and/or fabric manufacturing is also recommended.

Certification:

- ISO14001 is recommended

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Solution proposal	- Synthesis of the proposals in term of materials, bagging concept or any other innovative solution. - Development schedule.	To + 3 Months
D2	Auxiliary material sample presentation	- Manufacturing of samples (at least 1 batch per auxiliary material defined). - Presentation of product industrialisation.	To + 6 months
D3	Auxiliary material sample characterisation	- Technical report including the auxiliary material characterisation. (tension property, thermal property, spectrum...)	To + 9months
D4	Shop trials at lab scale and composites coupons manufacturing. (Panels of max 1m x 1m.)	- Technical report with shop trials in laboratory conditions including: product handle ability and composites coupons testing using the auxiliary material.	To + 12 months
D5	Shop trials in industrial conditions (Stiffened panels, approximate dimensions 2.5m*2.5m.)	- Technical report showing the use of material on industrial part.	T0+18 months
D6	Final report	- Synthesis presenting the solutions, materials, ... - Full material characterisation (if applicable) - Shop trials at lab and on real part. - Implementation plan.	T0+24 months

4. Topic value (K€)

The total value of the proposed package is

160.000,00€

[one hundred sixty thousand Euro]

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

5. Remarks

None

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-ECO-01-052	**Development of a fully automated preforming process for the production of 3-D shaped composite dry fiber profiles by using the energy efficient chemical stitching approach**	**Start date**	*T0*
		End date	*T0+18*

1. Topic Description

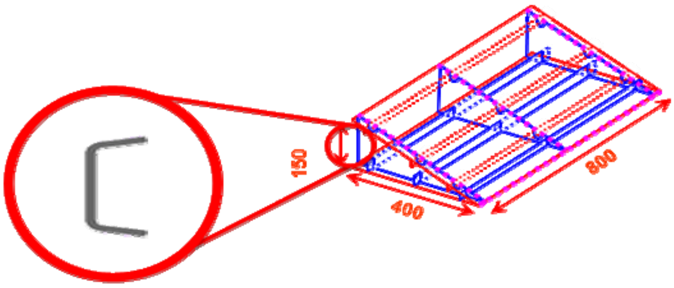
The objective is to develop an innovative fully automated preforming process for the production of dry continuous 3-D shaped composite dry fiber profiles. The system's main task should be to preform profiles made from dry composite fiber materials like carbon fiber roving and different types of fabrics (semi-finished products) by using the new and high innovative chemical stitching preform approach.

The development of an automated preform process for continuous dry preforms shall allow the use of energy efficient liquid composite moulding (LCM) processes for large volume production instead of the currently used time and energy consuming autoclave processes. The use of the new chemical stitching approach developed and evaluated within CleanSky (in lab-scale to produce small and flat generic samples) shall further allow the prevention of time consuming binder application and binder activation process by use of in-situ curing of the applied adhesive points by energy efficient curing methods e.g. IR- or microwave- technology. On the basis of the existing, within CleanSky developed lab-scale assembly, an equipment manufacturer is required to develop an automated solution which is suitable for the build-up of a stiffened panel demonstrator. The topic to bring the basic chemical stitching preform approach into an automated process requires a lot of research and development work from the equipment manufacturer caused by the singularity of the demanded process. In the preforming assisted by chemical stitching approach very small amount of the adhesive binder is used locally as a spot. Use of very less amount adhesive binder as a spot helps to maintain the permeability of the textiles. Hence the required impregnation time in the LCM process can be significantly reduced if compared to classically laminar bindered textiles. The automated preforming shall be developed to serve various applied research and development activities. However, the equipment shall be designed and built as compact as possible.

The categories of the produced parts are profiles such as tie bars, stringers or ribs which are used in aircraft construction in high numbers. The aim of this call therefore is to develop and build up a fully automated preform processing-line for the production of 3-D shaped composite dry fiber profiles by using the energy efficient chemical stitching approach.

The following steps shall be performed by the applicant:

- Development of effective concepts for a gentle supply of dry bindered and unbindered textile carbon- and glassfibre semi-finished products (like mats, veils, unidirectional and woven structures)
- Development of effective concepts for automated combination of these above mentioned individual semi-finished product single-layers to continuous fibre-packages or fibre-strings with a defined number of layers (number of layers should be adjustable before every production cycle)
- Development of effective concepts for forming of the previously produced fibre packages to profile structures like the bellow shown C shaped tie bars or T-stringers at a given geometry (area cross-section of the profile maximum 30cm²).



- Development of effective concepts for the fixation and stabilization of the formed single layers to a handable dry preform by using the energy efficient chemical stitching preforming approach. The binders have to be applied by injection needle with an inner diameter of maximum 1 mm. The binder material can be a hot melt (thermoplastic material) or reactive binders (curable thermoset material). The curing method for the reactive binders should be an energy efficient curing method.
- Evaluation of the presented concepts based on ecological requirements, as well as cost. One solution for each step will be selected and detailed.
- Build up of the assembly and performing first preform trials.
- Production of demonstrator profiles (C shaped tie bar), which are ready for infiltration and integration in CS EDA WP2 Demonstrator A4 “Aileron of Do 228” (picture above).
- Evaluation of the preform-line according to the assessment plan and ecological requirements.

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

Skills:

- Expertise in production of dry carbon-fibre preforms
- Good knowledge in automation of CFRP processes along the whole process chain (cutting, handling, draping, preforming and infiltration)
- Preliminary background (e.g. process idea, advantages, and process steps) for integrating the chemical stitching preform approach.

Equipment:

- Equipment length: the initial maximum available length for fixed built machine parts is 10,0m
- Equipment width: the maximum available width for the equipment (including area on both machine sides for the operator) is 4,0m
- A supply frame for the fibre products shall be used to support both glass fibre and carbon fibre semi-finished products having different orientations (mats, veils, UD, woven)
- The equipment shall be capable of accommodating atleast 5 different types of semi-finished materials so that preforms having minimum 6 fabric layers can be manufactured (minimum roll diameter = 200mm)
- It shall be possible to use different preform forming-tools (flat-profile, C-profile, T-profile) easily

- Individual temperature regulation for binder activation up to 250°C along the length
- Dosing system for injecting minimum amounts of reactive binder systems for chemical stitching (min. 4mg per injection point)
- Minimum density of injection points: 1/cm^2
- Process controlling over control computer
- Interface for real time input and output of all control parameters and possibility of external control programming.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Design-concepts of the preform production line	Report/ppt-presentation: CAD generic model	T0 + 4
D2	Detailed construction of the preform production line	Report/ppt-presentation: CAD detailed model	T0 + 10
D3	Build-up of the assembly and first preform trials	Report/ppt-presentation: Evaluation of the first trials	T0 + 15
D4	Optimization of the process to achieve the demonstrator geometry	Report	T0 + 17
D5	Production of demonstrator profiles (C-stringer) and evaluation	Report	T0 + 18

4. Topic value (K€)

The total value of the proposed package, is

300.000,00€

[three hundred thousand Euro]

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

5. Remarks

None

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-ECO-01-053	**Disintegration of fibre-reinforced composites by electrodynamic fragmentation technique**	**End date**	*T0 + 20*
		Start date	*T0*

1. Topic Description

Recycling of CFRP's like thermosets, thermoplasts (especially PEEK) or similar fibre-reinforced composites with the goal to separate the embedded carbon fibres from the surrounding polymer matrix is a difficult task. The processing of CFRP's by mechanical grinding methods results only in comminuted samples, but not in a selective detachment of the fibres from the polymer matrices which mainly consist of epoxy based binders or polyether ether ketone (PEEK). Furthermore, carbon-fibres can be damaged by the impact of crushing mills which reduces significantly their recyclability. Other processes like pyrolysis or chemical treatment methods seem to be too energy or material demanding to become economically viable. A promising method to disintegrate fibre-reinforced composites or fibre-metal-laminates selectively into polymers and fibres is the so-called electrodynamic fragmentation, which is a special adaptation of a pulsed power processing technique. This method is based on the physical principle that an electrical discharge in a solid takes preferably the line along phase boundaries and thereby disintegrates a composite into its compounds. If the process is conducted in a closed vessel filled with water or other suitable dielectric liquids, the electrical discharge generates shock waves, which intensify the disintegration.

The objective of the call is to implement a specific electrodynamic fragmentation technology for processsing CFRP's. A fragmentation of CFRP's into their main constituent parts fibres and polymers (+ metals) will significantly increase their recyclability. The focus is on the processing of thermosets, thermoplasts (esp. PEEK) and fibre-metal-laminates with the goal to regain non-damaged high-quality carbon fibres, which can be reused with no or minor post-treatments. Therefore the design and construction of a pulsed power processing plant specifically for CFRP's have to be carried out by the applicant.

A suitable partner shall perform the following tasks:

Task 1: Definition of process parameters and delivery of equipment specifications:

Initially, various samples of thermosets, thermoplasts (esp. PEEK) and fibre-metal laminates shall be used in a lab-scale plant to evaluate the optimum machine and processing parameters.

Following machine parameters are required for a pulsed power processing plant for CFRP's:

• High voltage (HV) cascade generator with variable voltage between 90 – 200 kV

• Variable pulse frequency between 1 – 5 Hz or higher

• Movable electrodes to keep the optimum distance between electrodes and sample constant

• Variable electrode configurations (bulging disc, finger-shaped, mushroom-shaped, etc.) and variable electrode material (working steel, stainless steel, machine steel)

• Plant must possess an automated electrical grounding

• External tool for monitoring resistivity and currency per pulse

Task 2: Evaluation of optimum parameters for processing CFRP's on lab-scale plant and provision of necessary input data for up-scaling and construction of a prototype

• Optimisation of most important parameters: a) distance between electrodes and samples and b) energy input (applied voltage).

• Maximisation of degree of deliberation (weight ratio of deliberated fibres / non deliberated fibres + polymers) as a function of energy input and electrode distance.

• Delivery of carbon fibres to project partners (recyclability of the obtained "deliberated" carbon fibres will be assessed externally for quality assurance)

If necessary, the process vessel and sieve inserts have to be modified in terms of shape and material.

Task 3: Concept for up-scaling, design and construction of a demonstrator

• Design of a continuously operating demonstrator with a high throughput rate for processing CFRP's, especially for thermosets, thermoplasts (esp. PEEK) and fibre-metal-laminates

• Design of a processing vessel suitable for samples with at least 20 cm x 20 cm x 5 cm in size, ideally is a processing area for large or complex samples (> 1 m in length) e.g. for fuselage samples

• Apply a suitable filtration process to separate the carbon fibres from the process water

• Assurance of health and safety issues:

1) Achievement of EMC (Electro-magnetic compatibility), where different electric and electronic systems of the demonstrator have to operate without disturbing each other.

2) Apply EMS (electro-magnetic shielding) to guarantee a safe handling of the processing plant and the operators.

• Performance test and a cost – energy efficiency analysis have to be conducted

The applicant may seek external support (subcontracting) with regard to physical and chemical analysis of products if needed. Analysis will also be performed by Clean Sky project partners for quality assurance.

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

The applicant (single organisation or consortium) should possess following:

• highly skilled in the development and adaptation of electrodynamic fragmentation techniques

• vast experience in mechanical engineering to design and build pulsed power processing facilities for various sorts of materials

• wide activity in the area of processing and recycling of composite materials

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Set up of equipment for machine and process parameters		To + 3 Months
D2	Optimisation of machine and process parameters on a lab-scale machine	Report	To + 6 Months
D3	Up-scaling, design and construction of a demonstrator	Technology transfer	To + 16 Months
D4	Evaluation of demonstrator performance and cost-energy efficiency analysis		To + 19 Months
D5	Final report		To + 20 Months

4. Topic value (K€)

The total value of the proposed package, is

435.000,00€

[four hundred thirty five thousand Euro]

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

5. Remarks

Fulfilment of all the requirements is mandatory.

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-ECO-02-013	**Electrical Test Bench Generic Configuration Behavioural Electrical Network Analysis Model**	End date	T0 + 18 months
	Design, implement, verify and validate the behavioural level computer implementation of the Electrical Network Analysis Model for the Electrical Test Bench Generic Configuration.	Start date	T0

1. List of Acronyms

AC: Alternating Current
A/C: Aircraft
CfP: Call for Proposal
DC: Direct Current
EDS: Eco Design for Systems
ENAM: Electrical Network Analysis Model
EPGDS: Electrical Power Generation and Distribution System
ETB: Electrical Test Bench
GA: Generic Architecture
HVDC: High Voltage Direct Current
ICD: Interface Control Document
ITD: Integrated Technology Demonstrator
JTI: Joint Technology Initiative
TBD: To Be Defined
VS: Vehicle Systems

2. Topic Description

BACKGROUND

EDS Electrical Test Bench (Copper Bird)

Within EDS ITD framework, test activities will be performed to validate the methodology and associated models to optimize complete a/c Vehicle Systems architecture for an all/more-electric aircraft.

The tests will be performed on a ground *Electrical Test Bench* (ETB, *Copper Bird*) representing the *Generic Architecture* as defined from the architecture down-selection and common to all small a/c types (i.e., business jet, regional a/c and rotorcraft). Representative a/c equipments will be connected to the simulated electrical network.

The main purposes of electrical test activities will be:

- “Real-Life” evaluation of key electrical technologies;
- Capture both steady-state and dynamical behaviours of equipment based on these technologies;
- Study in detail electrical transients;
- Measure actual network quality.

Most of the tests will be conducted on the generic architecture and will be common to the three small vehicle types (business jet, regional a/c and rotorcraft), while some specific tests, if relevant, could be added for the different vehicle types.

SCOPE OF WORK

Electrical Network Analysis Model (ENAM)

On an all/more-electric Vehicle Systems a/c, electricity will be major (maybe the only) media for the energy management. As a consequence, the power level and the interaction between subsystems through the network will be very high. In addition the single energy media increases the common mode failure risk.

Within EDS ITD, the *Electrical Network Analysis Model* (ENAM) is a representation of the electrical test rig. The main objective of the Electrical Network Analysis Model (ENAM) is *to validate a Vehicle Systems (VS) architecture with respect to electrical network quality through short term transient analysis*.

Other objectives of the ENAM can be listed in the following way:

• *Modeling electrical components of the Electrical Test Bench before integration*; the ENAM will demonstrate the capability to anticipate problems on the test bench.

• *Modeling the electrical test bench*; the ENAM will be a representation of the electrical test rig, where the ENAM and the ETB both contribute to the same goals (the rig extends the model into physical phenomena which are not modelled, the model extends the rig into configurations or parametric changes which cannot be physically performed on the rig).

• *Validate the methodology for electrical modeling*, in order to model the electrical network of the studied VS architecture and validate it with respect to electrical network quality through short term transient analysis.

The level of ENAM modeling will be at *behavioral level*, including but not limited to:

- *Short Term Transient;*
- *Switchings included;*
- *Failure Modes;*
- *Power and Weight behavior.*

ENAM shall be delivered in *SABER* format.

Equipment suppliers will provide models of the electrical interfaces of equipment and subsystems, at the level of detail required to reach the goals of the rig and models.

DESCRIPTION OF WORK

General Requirements

- Given the above scenario, the selected Candidate shall design, implement, verify and validate the *behavioural level* computer implementation of the Electrical Network Analysis Model for the Electrical Test Bench Generic Configuration.
- The ENAM shall be developed for the evaluation of aircraft on-board electrical power system with respect to different vehicle systems small a/c architectures. A dedicated analysis procedure shall be used to analyse the electrical network quality through short term transient analysis, which is the main issue of the model.
- The model shall be used to analyse (simulate and optimise) the following aspects:
    - *Power Quality & Stability Analysis*,
    - *Failure Mode and Selectivity Analysis (Reliability)*,
    - *Power & Weight Behaviour*.
- The model shall be delivered in SABER format (version 2009.12).

Model's Level of Detail Requirements

- Source code models with access to internal model variables and parameters shall be required. Black box models are not acceptable.

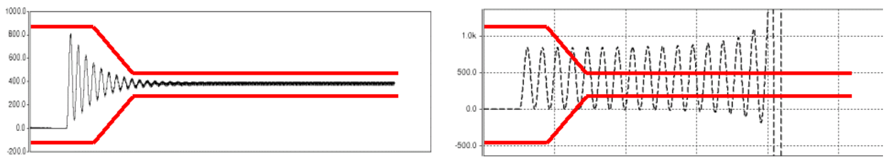
Power Quality and Stability Analysis Requirements

Power quality

- Due to the introduction of new technologies/systems like controlled speed motors (electric flight control actuators, fans…), the time scales of simulations are short (a few AC periods) and the phenomena to be studied are particularly sensitive.
- Based on MIL-STD-704F standard, this analysis shall study the interaction between sources and loads on electrical power quality, filtering, the interaction between subsystems, *all with short term transient analyses*. In particular, these analyses shall focus on:
  - AC current harmonic rejection of loads and their impact on network voltage distortion;
  - AC network power factor;
  - AC and DC current and voltage waveforms after load switching;
  - DC network ripple;
  - Potential resonance of loads' input filters.
- The power quality analysis shall be done with behavioural modeling.

Stability

- Unlike the stability definition in the control theory, the stability criterion in the industrial standard is usually formalized with the ability of a system to keep a certain system variable of interest within desired limits, which can be given in time domain or frequency domain. In particular, stability for electrical network is the ability of the voltage regulation to keep the voltage at Point of Regulation (PoR) within limits specified by the relevant standard, in either steady-state or transient operation, and either normal or abnormal condition.



STABILITY INSTABILITY

Stability criterion in the industrial standard

- Some electrical standards shall be considered for defining the acceptable limits. Thus, the voltage has to stay in specified limit even in transient operations (MIL-STD-704F standard).
- The time scales of these simulations are greater than for power quality studies. The aim of those simulations shall be to analyze, for both AC and DC networks, the energy transfers between the generating systems and the loads in order to detect any stability problems concerning energy transfers:
  - Network voltage stabilization during load power transients;
  - Impacts of network voltage transients on loads power consumption;
  - Detection of potential steady-state frequency modulations.
- It shall be important to identify some key parameters that are sources of instability or stability for the a/c electrical network. These parameters will have to be industrial ones, i.e., they will have to be testable with simple tests on equipments.
- Due to the behavioural level of modeling, the stability analysis could be even performed by using theoretical stability criteria, provided that it will be possible to extract from the model simulation the

features as adequate indicators of the overall system stability.

Failure Mode and Selectivity Analysis Requirements

- This analysis shall consist in assessing the protection strategy in case of over-current, over-voltage, over-temperature, short circuits, open circuits, connection and disconnection of loads. It shall also look at reaction time, threshold with available measurement and monitoring capabilities. It shall examine cores logic and protection systems, network reconfiguration, algorithms for load shedding, degraded system states for dispatch, reliability of the system.
- The reconfiguration capability of the electrical system shall be built into the corresponding system model by including the open / close logics of the various bus-bar switches, which link (or disconnect) the power generators and users through the electrical network. This allows to simulate the system model for various normal and abnormal operational scenarios, e.g. for system operation in degraded state subsequent to component failures.
- Failure mode and selectivity analyses shall be done through behavioural or functional modeling. This shall include:
  - Protection strategy in case of failure mode detection;
  - Operational management of the electrical system, i.e. switching of bus bar contactors for normal and abnormal system operation;
  - Innovative/intelligent load management model, i.e. algorithms for shedding and/or degrading of non-essential loads in cases of electrical system degradation;
  - Reliability of the system.

Reliability Analysis Requirements

- The reliability analysis shall rely on the capability of a system model to simulate various operating modes, i.e., it shall draw on the normal, degraded and failure behaviour at system level, which in turn is based on a description of the normal and failure behaviour at component level.
- The model shall provide automated means to compute the reliability of voltage and power supply to a single or several bus-bars (the above function shall be fully integrated with the model).
- For user defined system level events, such as the availability (or loss) of voltage and power on a single or several bus-bars, this analysis procedure shall automatically identify the combinations of intact components that cause the system to operate corresponding to the user defined event.
- The probability of occurrence of the system level event shall be computed, as well as the importance of system components. The importance of a component is a measure for its structural and probabilistic influence on the probability of occurrence of a system level event. Cognition of the component importance will help to identify potential weak points or unnecessary redundancies in the electric system architecture.
- The reliability analysis procedure shall be based on the failure behaviour contained in the system models. At the start of a system reliability analysis, it shall be possible also to set some components as initially failed. Then, the procedure shall compute the probability of system failure, as well as components importance for the initially degraded system. This is a useful feature with respect to the assessment of dispatch reliability: it should be possible to clear the aircraft for flight even if not every system component is functional (MMEL dispatch), provided that safety of flight is ensured.

Power & Weight Behavior Requirements

- By simulating a system model, the maximum load / power / current to be carried by each component of the electrical system shall be determined. This will lead to a sizing of the components and to an estimation of their weights. Then, the model shall determine the total system weight by automatically adding up the individual weights of all components contained in the system model.

- The weight and power analysis procedures shall be implemented in the model library and shall be processed simultaneously with the system model.

Other Model Requirements

Detailed Model Features

- The model shall represent the electrical behaviour of the equipment, such as current demand in steady-state and during transients changes of component operating point (e.g., due to shifts of mechanical load (speed, torque) at actuators or motors, or due to voltage shifts/transients at network level).

Electrical Components Models

- The selected Candidate will receive as an input the behavioural electrical models of all the available equipment composing the Generic Configuration of the ETB and provided by the equipment suppliers. The electrical components models will be delivered in SABER format. All the components models which will not be available by the suppliers shall be covered by the Candidate (to the extent of its modeling capabilities) through a dedicated electrical system library.
- Four categories of equipment shall be considered:
  - A) power generators;
  - B) power transformers and converters;
  - C) power transmitters: cables, switches, circuit breakers, power distribution centres;
  - D) power users: motor drives, heaters, lighting etc.

- The level of detail and effects included in the electric component models shall be commensurate with the whole system model objectives, i.e., to analyse and optimise the power behaviour, weight and reliability of aircraft electric power systems.
- Each component model, e.g., that of an electrical wire or generator, shall include a description of:
  - the dependency of the component weight on sizing parameters, such as nominal power, nominal voltage and / or current, nominal speed, whatever is applicable,
  - the electrical characteristics with regard to voltage drop, current flow, resistance, efficiency and/or power demand for the normal operation of the component,
  - Analogously, the electrical characteristics for the failed condition of the component. as well as the failure probability.

  This kind of component modeling shall be the basis for the determination of the power behaviour, weight and reliability at system architecture level.
- For equipment behavioural models:
  - Operating mode of behavioural models shall take into account the real impedance of the equipment seen from the network (purely resistive loads are insufficient); constant load shall be represented, if necessary;
  - Operating mode of behavioural models shall take into account of de-phasing, if it exists, it shall be representative;
  - Behavioural models shall integrate all network filters, lightning protections of the real equipment;
  - The consumption shall be representative of the real even for the equipments composed of switching devices (transistors);
  - If an equipment operates with voltage thresholds, for example an hysteresis effect for a relay,

the model shall integrate these thresholds;

- Switching delays shall be representative;
- For the equipments performing like a generator, a current saturation shall be taken into account.

- The physical modeling of the components operational and failure behaviour shall be an essential to the reliability analysis. By putting together an electrical system model from the described component models, the normal, degraded, if applicable, and failure behaviour can be studied and checked at system level.
- Each component shall be delivered with all documentation necessary to understand the modeling, utilisation limits of the model, main simulations of the single model.
- To follow the evolution of models, a version system shall be implemented to distinguish issues.

Electrical Systems Library

- The model shall comprise a dedicated electrical systems library containing a comprehensive set of object-oriented, physical models of electrical power system components designed to model the dynamic behaviour of electric systems.
- The library shall be hierarchically structured to accommodate various models of different complexity, such as interfaces (plugs, data-buses etc.), basic electrical components (wiring, switches, bus-bars etc.), more integrated electrical components (generators, rectifiers, converters etc.), power users (motor drives, heaters etc.) and entire system architectures. Thus, the library shall provide an infrastructure for the creation or adaptation of simulation models of electrical system architectures.
- The library shall incorporate elements such as:
  - Electric machines (motors / generators);
  - Machine types represented (commutated DC machines; three-phase AC machines; special purpose machines);
  - Power electronics (converts one form of electrical power to another, i.e., AC to DC, one DC voltage to another, etc.);
  - Controls (adjusts machine inputs to control machine speed, torque, power or voltage).
  - Passive networks (resistive, inductive and capacitive networks for modeling electrical interconnections and loads);
  - Sources and Loads (batteries for storing energy, rotational inertia, mechanical loads, etc.);
  - Electronic Power Options (switch mode; continuous).

Signal Analysis Tool

- An adequate signal analysis and measurement tool (i.e., a behavioural model for power quality and stability studies) of aircraft electrical power system shall be required. As a matter of fact, besides modeling and simulation, the measurement of simulation results is also interesting and important for engineering tasks, e.g. the stability and power quality issues for the a/c electrical network.
- The signal analysis and measurement tool may be also realized in an environment different from SABER (e.g., Matlab) with a dedicated GUI loading simulation data from SABER and then performing all the following features (including power quality and stability analysis):
  - User-friendly graphical interface;
  - Powerful signal processing;
  - Advanced functionality of plot (zoom, export, comparison, etc.)

- Stand-alone software, no third party license required.

- The program run of the measurement tool for a signal analysis task shall contain the following main procedure:
  - Initialization phase:

    Loading the simulation result file;

    Representing all model variables in a tree structure, which allows the user to easily browse and select signals and parameters;
  - Post-processing phase

    Plotting the selected model variables;

    Performing various measurement calculations on selected signals and graphical presentation of the results;

Inputs

The following inputs will be distributed to the selected Candidate at the early stage of the Project:

- Rig Electrical Power Generation and Distribution System architecture (electrical scheme of EPC);
- Equipment List, describing in details the characteristics of the ETB power consumers;
- All the available models of ETB equipment from the suppliers with associated documentation.

WORK-FLOW

The Candidate activity shall include:

- Detailed study of the solution;
- Development of the model;
- Verification and validation of the model;
- Optimization of the model.

The selected Candidate shall provide technical documentation (reports) for each of the major activities. In particular, a final report with the results of validation phase shall include possibilities for further investigations and optimizations of the system, either regarding the core controller and the switching components.

The Candidate shall include in the proposal a validation matrix and plan for the development of the model. In particular, the candidate shall propose a set of significant test cases in order to step by step validate the functions and performances of the developed model.

The Candidate shall include in the proposal a risk matrix with associated risk severities, probabilities of occurrence and mitigation aspects.

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

The Candidate organization shall have:

- expertise in electrical system design (power generation, power conversion, power network, power consumer),
- a well recognized experience in system simulation methods,
- knowledge of Industrial/Aeronautical field constraints and procedures,
- availability of basic simulation tools: at least a full SABER code licence
- good practice in English language,

The Candidate shall preferably rely on a certified background in development and validation of SABER models for aeronautical electrical equipment, particularly for research (national and/or european) projects. Theoretical research centers and universities are preferred due to their attitude to operate in a formal framework for modeling activities.

4. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Analysis	Detailed study of single equipment models and associated standalone validation tests. Single models integration in a specified ETB ENAM.	T0 + 3 months
D2	Development	Development of possible missing models. Power quality, stability and reliability tests arrangement. Development of post-processing tool in a simulation environment (SABER or equivalent).	T0 + 12 months
D3	Verification and Validation	Power quality, stability and reliability tests performing. Analysis and verification of tests results for ETB ENAM validation.	T0 + 16 months
D4	Optimization	User feedbacks analysis and optimization of ETB ENAM for requirements accommodation.	T0 + 18 months

5. Topic value (€)

The total value of the proposed package, is

250.000,00€
[two hundred fifty thousand Euro]

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

6. Remarks

None

Clean Sky – Green Regional Aircraft

Identification	ITD - AREA - TOPIC	topics	VALUE	MAX FUND
JTI-CS-GRA	**Clean Sky - Green Regional Aircraft**	**11**	**9,960,000**	**7,470,000**
JTI-CS-GRA-01	*Area-01 - Low weight configurations*		**4,260,000**	
JTI-CS-2012-1-GRA-01-042	Advanced Floor Grids for Green Regional A/C. New concept of design, manufacturing and installation in Ground Full Scale Demo		2,200,000	
JTI-CS-2012-1-GRA-01-043	Smart Distributed Sensory Systems		260,000	
JTI-CS-2012-1-GRA-01-044	Design, development and realization of a novel micro-wave based curing device for out-of-autoclave carbon fiber reinforced composite		150,000	
JTI-CS-2012-1-GRA-01-045	Advanced Liquid Infusion Tecnology for regional wing structure: Numerical simulation and validation through an innovative test bench		330,000	
JTI-CS-2012-1-GRA-01-046	Collapsible Tooling Proposal for a/c nose fuselage & cockpit		300,000	
JTI-CS-2012-1-GRA-01-047	Advanced light pressure bulkhead for a/c cockpit		320,000	
JTI-CS-2012-1-GRA-01-048	Modelling and Simulation of a self sensing Curved composite panel to predict/control damage evolution in real load condition		400,000	
JTI-CS-2012-1-GRA-01-049	Optimal tooling system design for large composite parts		300,000	
JTI-CS-GRA-02	*Area-02 - Low noise configurations*		**4,300,000**	
JTI-CS-2012-1-GRA-02-019	Transonic NLF wing and LC&A integrated technologies: Experimental Validation by Innovative WT Tests		4,300,000	
JTI-CS-GRA-03	*Area-03 - All electric aircraft*		**1,400,000**	
JTI-CS-2012-1-GRA-03-009	Advanced Flight Control System – Design, development and manufacturing of EMA with associated ECU and dedicated test bench		1,100,000	
JTI-CS-2012-1-GRA-03-010	Control Consolle and Electrical Power Center per Flight Demo		300,000	
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-2012-01-GRA-01-042	**Advanced Floor Grids for Green Regional A/C New Concept of Design, Manufacturing and Installation in Ground Full Scale Demo**	**End date**	$T_0 + 12$
		Start date	T_0

1. Topic Description

Scope of work

Scope of this activity is *to provide a complete shipset of floor grids for the Full Scale barrel* developed by a new process for composites.

The new process shall be automated; moreover it will be flexible in order to fit the different shapes in aspect and ratio, typically needed in aerospace.

The Progressive Roll Forming (PRF) of Thermoplastic Carbon Reinforced Polimers (TCPFRP) should be a feasible innovative manufacturing process which matches the above mentioned characteristics. Moreover similar manufacturing process could be considered as valid alternative to PRF.

In order to support process development, fixtures, moulds and plants will be designed and manufactured for each component of floor grid.

Objective of innovative and automated process manufacturing is weight reduction and save cost.

Introduction

This proposal describes the activities to be done for the design and manufacture of composites Pax and Cargo Floor.

The activity is envisaged within the JTI – Clean Sky Program for the *GRA Low Weight Configuration Domain.*

The PRF should be a suitable manufacturing process since Thermoplastic Composites (PEEK, PKK, PPS) allow avoiding of chemical processing for the matrix, plus the possibility to introduce additional processing features like successive forming and welding. Moreover autoclave cure is not needed since usually hot mould in mechanical press will be adopted and the cost increasing of TPCRP can be recovered not only by weight reduction, due to improved mechanical features, but especially by the possibility to make the manufacturing process automated.

The applicant can suggest the material type (composite, thermoplastic, metal etc.) to manufacture all parts. Based on the applicant selection, Topic Manager will provide material spec if available.

Interfaces to ITD

A kick-off meeting will be held at the beginning of the project object of the CfP in order to supply all necessary details in terms of final geometry of floor/fuselage barrel interface and respective loads.

The general dimensions of the items objective of the present CfP are instead showed in Activity Description paragraph.

Activity Description

Making some analogy with extrusion process, in the new automated PRF process, several thermoplastic basic layers (single plies or consolidated sheets) will be pulled through a matrix, but in this case the matrix is composed by different wheels giving the desired shape. The basic layers (more than one) will be heated up and then cooled after consolidation and forming: the material will be simultaneously deformed and compressed passing through the rollers.

The activity is divided in four work packages:

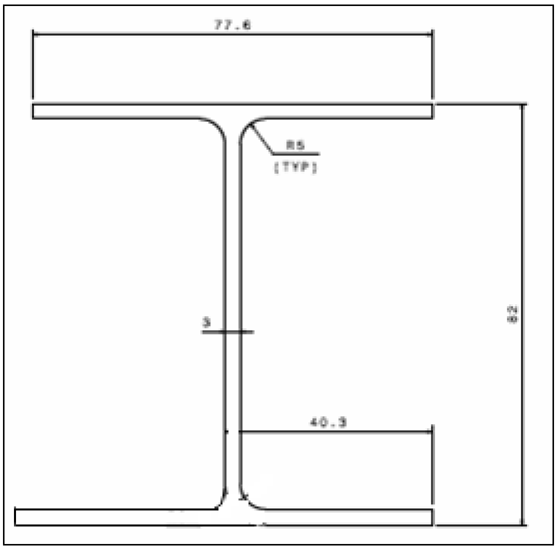
WP1 – Design

Pax Floor and Cargo Floor will be designed.

In details for Pax Floor (see fig.4 as reference only), the following elements will be designed:

-Floor beams (about 3 m long for 9 stations)

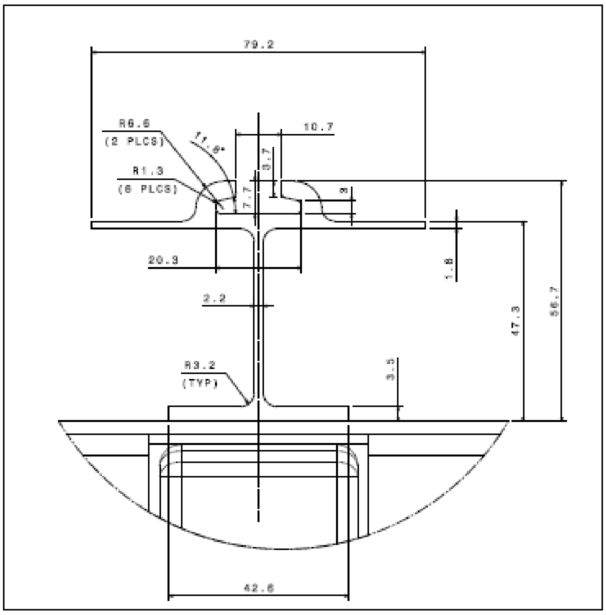
The floor beams section is shown in the following figure:



Fig, 1 Floor beams section (as reference only)

-Seat rails (Nr. 6 about 4,9 m long)

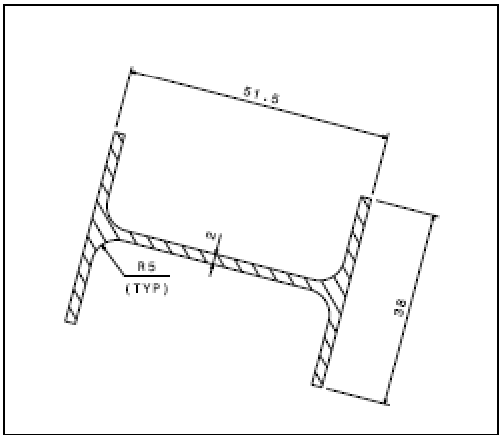
The Seat rails section is shown in the following figure:



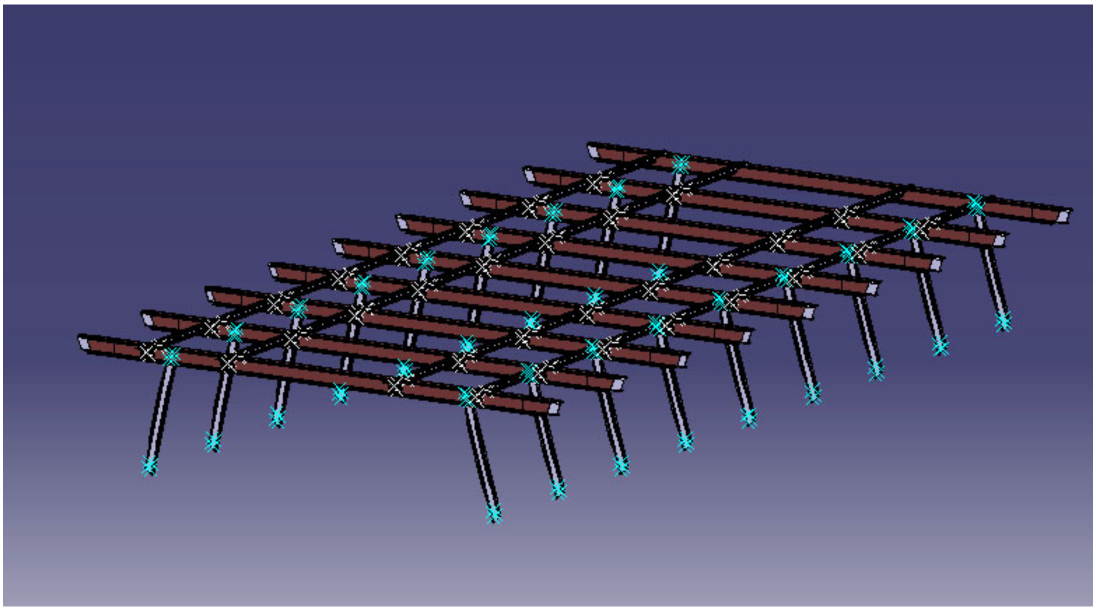
Fig, 2 Seat rails section (as reference only)

-Stanchions (for 9 stations about 0.8 m long)

The Stanchions section is shown in the following figure:



Fig, 3 Stanchions section (as reference only)



Fig, 4 Pax Floor (as reference only)

For Cargo Floor the following elements will be designed.

-Floor beams (about 1,1 m long for 9 stations)

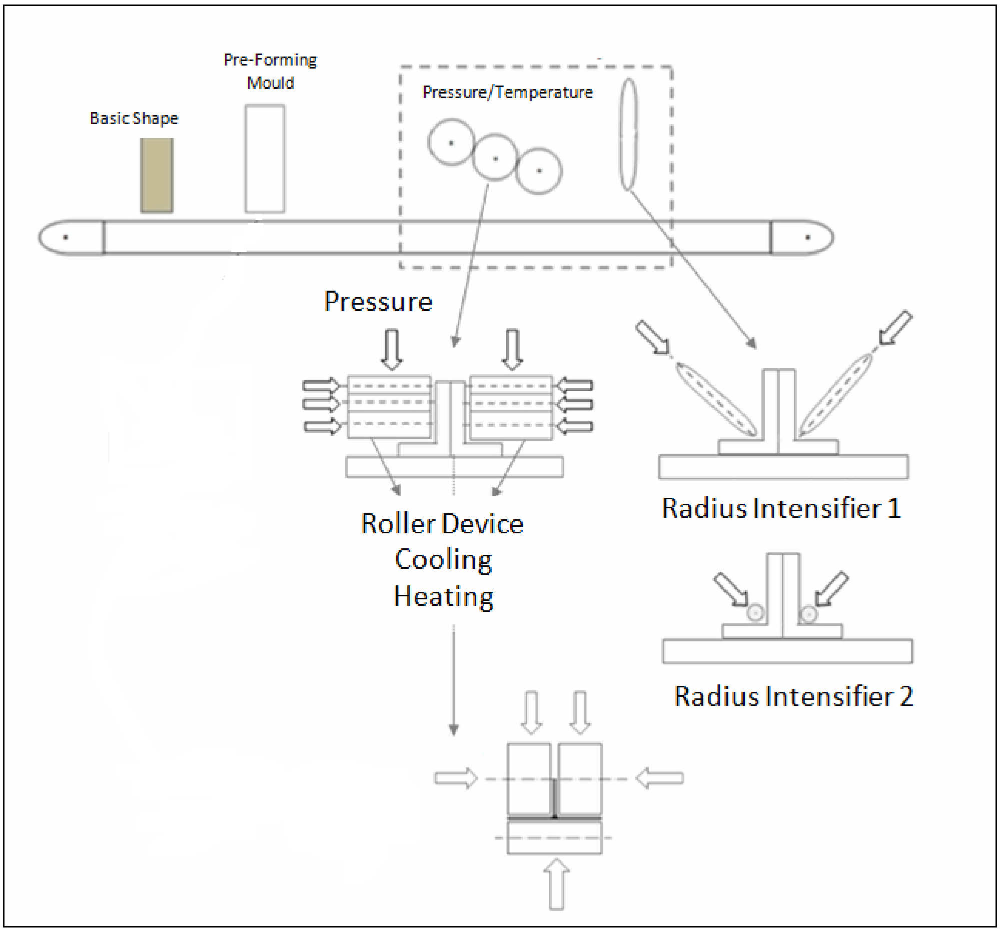
All detailed CAD and FEA model will be provided by the Applicant.

WP2 – Technology Development

Prototype components will be manufactured to set-up and validate the innovative process.

Initially the process will be validated by simple shape, then for more complex shape, for example C-Shape or T-Shapes. The deformation could be provided by rolling, applying special devices for hi-curvature areas.

A simplified scheme of an innovative PRF process is shown below as reference only.



Fig, 5 simplified scheme of an innovative PRF process (as reference only)

WP3 – Tools for manufacturing and assembling – Design and Fabrication

In this WP all tools for manufacturing and assembling of above mentioned specific components will be designed and fabricated according to the outcome from the activities performed to develop and set up the innovative process.

WP4 – Manufacturing and assembling

In this WP all components designed in WP1 will be manufactured.

The final Pax Floor and Cargo Floor will be assembled and provided to ITD for the integration in the fuselage barrel.

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

The applicant shall have a proven ability in the production of aerospace innovative composite structures having high performance and all the relevant production equipment needed for the complete manufacturing and assembling of full scale components.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
Del.1	Pax Floor and Cargo Floor Design	The deliverable consists of: • technical report (full details on the design of all components); • related FEM • related drawings	T0+4
Del.2	Process validation	The deliverable consists of: • Technical report (full details manufacturing technology); • Prototype sub-components manufactured in order to validate the process	T0+6
Del.3	Assembling and manufacturing tools	The deliverable consists of: • Technical report (full details on assembling and manufacturing tools); • Assembling and manufacturing tools fabricated	T0+9
Del.4	Pax Floor and Cargo Floor manufacturing and assembling	The deliverable consists of: • technical report (full details on the production of the all components): type of process, process parameters, critical aspects, quality concerns, etc. on full scale components. • Pax Floor and Cargo Floor assembled	T0+12

4. Topic value (€)

Budget: The Maximum Allowed Topic Budget is

2.200.000,00 €

[two million two hundred thousand Euro]

The maximum funding value is between 50% and 75% of the Maximum Allowed Topic Budget indicated above according to the CfP rules.
Please note that VAT is not applicable in the frame of the Clean Sky programme

5. Remarks

During the period allocated for the CfP, additional information / requirements shall be provided by identifying materials, architecture, loads, in a joint preliminary phase to the contractor.

The contractor shall therefore adjust accordingly and embody the given information / requirements, prior to delivery of final product.

Clean Sky Joint Undertaking
JTI-CS-2012-01-GRA-01-043

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-GRA-01-043	**Development of a Wireless Smart Distributed System for aircraft applications**	**End date**	T_0 + 18
		Start date	T_0

1. Topic Description

Acronyms:

ADC: Analog-to-Digital Converter
BER: Bit-Error-Rate
COTS: Components-Off-The-Shelf
DC: Direct Current
DSP: Digital-Signal-Processing
FPGA: Field-Programmable-Gate-Array
HDL: Hardware-Description-Language
MEMS: micro-electro-mechanical systems
PCB: Printed-Circuit-Board
RF: Radio-Frequency
VLSI: Very-Large-Scale-Integration
WSN: Wireless Sensor Network

1.1 – Scope of work

The scope of this work aims at developing a Wireless-Sensor-Network (WSN), which possesses several features in order to be employed by the aerospace industry. These features mainly involve fault-tolerance, reduced weight, scalability, power autonomy, and adaptability (Figure 1). Therefore, certain architectural choices are imposed by the manufacturer. The requirements for enhanced reliability, reduced weight, and power autonomy imply that the system must be wireless, distributed and moreover, able to adapt its electronics/topology in order to compensate for anticipated events. The proposed WSN will be employed to in-situ monitor in real-time structural, operational and environmental parameters of aircraft systems.

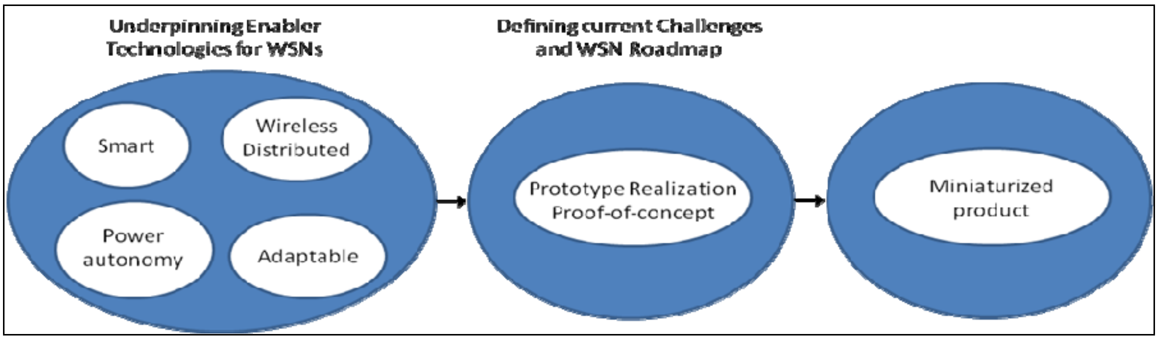


Figure 1 - Underpinning Enabler Technologies and Roadmap for WSNs

1.2 – Reference documents

N.A.

1.3 – Introduction

Propelled by safety, inspection cost-reduction, and legislation, nowadays, the demand for smart monitoring systems is rising. In aerospace and automotive domains there is a tremendous increase in the employment of real-time, smart monitoring systems which aim at increasing safety and reducing maintenance costs by continuously monitoring the functionality of electronics and/or the structural health of aircraft components.

1.3.1 - Background

Recent developments in Very-Large-Scale-Integration (VLSI) and micro-electro-mechanical systems (MEMS) technology and continuous advances in shrinking the geometry of a transistor have stimulated the realization of **Smart Wireless Distributed Systems**. Wireless distributed systems could be smart when they are able to adapt their functionality based on the occurrence of certain events. These systems mainly consist of the following components: sensor elements, signal conditioning electronics, analog-to-digital conversion, digital-signal-processing and control integrated circuits, data storage, radio-frequency units, dc-to-dc conversion modules, and energy harvesting units.

Based on the targeted application, a wireless distributed system could potentially consist of homogeneous or heterogeneous sensor nodes based on the physical entities to measure and the complexity of the hardware resources of the corresponding node. Subsequently, these nodes should be capable to adapt their connectivity and functionality according to endogeneous (ageing of electronics, anticipated/unexpected faults, low-battery-level of sensor nodes, process variation) and exogenous (temperature, pressure and humidity variation, sensor contamination, etc) factors.

On the contrary to a centralized system, wireless distributed systems present several advantages. Firstly, there is a significant reduction in the weight of the system since the need for long wires is eliminated. Apart from the cost reduction, the maintenance cost is reduced as well, since individual wireless sensor nodes can be easily substituted or new ones added. Hence, system scalability is an additional advantage that wireless distributed systems offer in comparison to centralized wired system architectures. In addition to the scalability, wireless distributed systems promote the concept of parallelism. Numerous sensor nodes operate at the same time to accomplish a specific task.

It is well known that in parallel multi-core systems a task can be accomplished in less time than a centralised system does, and then the unecessary hardware resources can be temporarily switched-off. Moreover, the WSN should have an adhoc topology, which enables adaptive routing among sensor nodes in order to preserve the energy of sensor nodes that run to energy exhaustion.

Another field in which wireless distributed systems present superiority over centralized ones is the dependability they provide. Due to their inherent redundancy, distributed systems can be designed to be fault-tolerant and continue operating in case of a fault. For example in a distibuted system, a malfunctioning sensor node can be replaced by another one, in the close vicinity, which can execute in a time-division manner the functionality of the faulty one as well. This re-allocation of task may impose a degradation in the overall system performance (increased latency) of the distributed system, but it still enables the system to continue operating within fail-safe margins. Moreover, it is very likely that similar sensors present variation in the obtained measurements due to several factors, such as manufacturing variation, ageing, contamination, and environmental conditions. Therefore, a reliable WSN should provide the capability to correct these inaccuracies by employing adaptive signal conditioning modules. Furthermore, several data fusion techniques, such as Kalman filtering, can be employed in order to initially identify faulty nodes and then estimate the state (measurements) of a faulty sensor node, by utilizing the obtained information by neighbouring nodes.

Moreover, due to the vast amount of data gathered by the network, specific precautions should be taken in order to minimize the bandwidth, memory and processing requirements. For instance data (de)compression tasks could be supported by the sensor nodes. On the top of this, elimination of the temporal and spatial data redundancy could be performed. Finally, in order to make more efficient utilization of the available bandwidth, an appropriate wireless communication protocol should be selected in order to decrease the rate of retransmitted data due to high interference resulting in high Bit-Error-Rate (BER). It is important that the network topology could also consider BER per link, than just considering the energy available levels of each sensor node.

1.3.2 – Interfaces to ITD

The work is integrated within the WP 1.5.2 activities

1.4 - Activity Description

In the completion of this project, a fully-functional WSN that monitors structural, operational and environmental parameters of aircraft systems will be realized. The final outcome will compose a prototype that combines the employment of custom hardware design and components-off-the-shelf (COTS) in order to reduce cost. The WSN will consist of a number (at least four) of sensor nodes, which present the capabilities introduced in Section 1.1 (Scope of Work) of this document. The sensor nodes, in-turn, will support a variety of sensor elements measuring different physical quantities, such as temperature, strain, pressure, etc. Moreover, each sensor node will incorporate a custom energy harvesting module that aims at harvesting energy by employing efficient sources from energy-to-weight ratio, perspective.

The contractor is responsible for the following tasks:

T1. The definition of a WSN specification that meets the requirements imposed by the aerospace industry.

- Several issues concerning the aerospace domain must be considered in order the prototype to meet the aerospace requirements from functional, safety, and structural, perspective.

T2. The hadware development of the different modules that could compose a sensor node. Some modules below will be designed from scratch, while others will be taken off-the-shelf. Certain sofware and hardware development must be carried-out in order to implement the required functionality

- Sensor elements
- Adaptive signal conditioning
- Analog-to-digital converter
- Radio-frequency unit
- Digital signal processing and control unit
- Energy harvesting unit
- Power management unit
- DC-to-DC converter
- Memory

T3. The functional testing of each of the hardware components developed in task T2.

T4. Firmware development of the sensor node hardware

- code debugging per unit

T5. HDL development of the global computation on FPGA

- develop intelligent algorithms plus wireless communication protocol or impement a existing protocol
- simulation testing of HDL downloaded to FPGA

T6. Sensor node integration with global computation

- validate the full loop from the sensor node to the global computation and vice-versa

T7. The scalable integration of a WSN that consists of an incremental number of sensor nodes.

- monitor the integrity of the data exchanged among the sensor nodes of the deployed network
- Testing of the functionality related to the power management protocol
- Testing of the functionality related to the communication and routing protocol
- Testing of the functionality of the data fusion algorithms

T8. Implement a demonstrator including several use-cases
- Define realistic use-cases that reveal the capabilities of the WSN concerning:
  - hardware adaptation
  - routing configuration based on power autonomy and signal interference
  - sensor nodes isolation in case of fault occurrence or power recovery
- Two use-cases will be demonstrated
  - the first will compose a generic proof-of-concept revealing all the capabilities mentioned above
  - the second will incorporate the utilization of the WSN on a real panel demonstrator (representative aircraft structure that will be defined by the topic manager)

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

The adequate applicant should have expertise in the following domains: Printed-Circuit-Board (PCB) design, System Integration, Digital-Signal-Processing (DSP), Artificial Intelligence, Hardware-Description-Language (HDL) development on FPGA, and Wireless Communication Networks theory.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Conceptualizing WSN architecture for in-situ real-time monitoring of aircraft systems.	This deliverable should define the architectural choices that have been made in the WSN in order to meet the requirements imposed by the aerospace industry.	$T_0 + 2$
D2	Sensor node architecture	This deliverable should describe the architectural details of a sensor node design.	T_0+5
D3	Global computation development	This deliverable should describe the global computation architecture (HDL development in the FPGA) that is gathering the WSN's statistics and taking several decisions for the configuration of various WSN parameters.	T_0+9
D4	Sensor node hardware implementation	This deliverable should describe the hardware implementation of the different units of the sensor node	T_0+10
D5	Sensor node firmware development	This deliverable should describe the firmware development of the overall sensor.	T_0+14
D6	Integration between Global Computation and Sensor node	This deliverable should describe the integration: the tests carried-out in order to validate the functionality from a sensor to the global computation, and vice-versa.	T_0+16
D7	WSN integration and testing	This deliverable should describe the details of a WSN integration and testing, consisting of at least 4 sensor nodes.	T_0+17
D8	Demonstrator description and full system delivered	This deliverable should include the fully functional sensor system on a demonstrator structure defined by the topic manager. This will summarize the final outcome of this work: the demonstrator of the selected use-cases will be described and results will be evaluated.	T_0+18
D9	Future Challenges and Roadmap for WSNs	This deliverable will summarize the work carried-out during the timeline of the project. It will also highlight the encountered technical obstacles and justify the selected solutions. Finally, it will raise future problems and challenges in the field of WSNs and provide a roadmap for the future.	T_0+18

4. Topic value (€)

Budget:

The total value of the proposed package is

260.000,00 €

[two hundred and sixty thousand Euro]

including all cost categories (personnel, computing, travels, etc.);

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

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-GRA-01-044	**Microwave assisted curing for carbon fibre reinforced epoxy composites**	**End date**	T0 +10
		Start date	T0

1. Topic Description

Carbon fiber reinforced composite parts are of great interest for the manufacture of aircraft industry because of their high potential in lightweight application combined with high mechanical strength. Curing process of CFRP components is a high time-consuming factor during manufacturing;for a cost effcient manufacturing process, reduction of curing time is surely one of the most important issues to take into consideration. Microwaves are suitable for rapid heating and therefore for fast curing of carbon fiber reinforced composites. C/F samples are electrically conductive and therefore the magnetic field generated by the microwave will be most important for heating C/F reinforced polymers. A multi-mode field will not yield an effective heating. Since the heating profile is different compared to the conventional heating and therefore curing, the questions that arises is, if the material properties of microwave cured samples are different compared to those manufactured with the conventional process; Furthermore the deformation of the sample as a result of heating through the cross-section and curingof the sample must be considered. A key role for the whole heat management and therefore for the final properties of the cured sample is played by the mould. A suitable and for this purpous dedicated mould design will bring clear advantages for the curing and final quality of the sample. All above mentioned parameters, like material and material properties,heat balances, sample deformation, must be carefully taken into consideration due to their role. The purpose of this call is to enhance theengineering process of CRFP manufactured by means of microwave assisted curing. The main objectives of this call are:

a. Investigation of the influence of additives in the resin for microwave absorption and curing
b. Investigation of the influence of microwave itself on sample properties, including shrinkage and deformation of the manufactured part
c. Determination of limitation of geometry and shape of a part for example maximum radius of curvature, maximum length of bar and maximum depth of holes for MW curing purposes.
d. Design of the mould and selection of mould materials for minimum deformation and abrasion wear for microwave assisted curing for the future step of the demonstration parts
e. Economical and ecological assessment in comparison to cenventional cured parts

According to the objectives the following work packages are resulting:

WP1: Material and sample investigations

In WP1 additives will be selected to enhance the interaction of the microwave. The additves will be mixed in the resin and C/F sample will be prepared by means of vacuum assisted infusion technology. The so prepared samples will be cured with microwaves. The degree of polymerisation of the cured samples will be measured and evaluated. The deliverable is a list of additives which are compatible with the epoxy resins and enhance the interaction with microwaves to lead to a complete curing.

WP2: Investigations of the microwave cured samples

The heating profile and therefore the curing with microwave heating is completely different to conventional heating or rather curing. The important differences are the inverted temperature profile and the sectional heating of the sample. Investigations to find out the differences of microwave cured samples will be the focus of the work. Samples (microwave-cured & conventional-cured) will be prepared under the same conditions in particular resin and lay-up, fiber type. Mechanical tests, DSC and chemical stability will be tested. Tests include also investigations of distortion on flat samples to assess possible effects generated by the microwave curing. The dimensions of the flat samples will depend on the measurement equipment of the distortion analytics and will be agreed along with the CfP-partner.

WP3: Determination of geometrical limitation of the microwave curing

The magnetic field will be applied on the samples to be cured with a special microwave antenna system. The content of the WP3 will be the investigations concerning the geometrical limitation resulting from the form of the antennas.

WP4: Design of a mould

Because metal moulds are not ideal for microwave assisted curing, non-metal materials will be selected for the mould; after material selection, the mould is designed with computer aided design.

WP5: Economical and ecological assessment

A viability study on the economic and environmental impact of the new curing technology (LCA, recyclability) will be performed. An analysis of the logistics and economical aspects of operation of the whole process s will be carried out to successfully scale-up the process to the industrial scale. Comparison between microwave accelerated and conventional curing will be performed

	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
WP1: Material and sample investigations										
WP2: Investigations of the mw cured samples										
WP3: Determination of geometrical limitation of the mw curing (3-D)										
WP4: Design of a mould										
WP5: Economical and ecological assesment										

MS1 after M5: Material and sample investigations completed

MS2 after M9: Design of the mould completed

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

Skills:

- Expertise in microwave technology in particular curing of composites with microwaves
- Expertise in polymer engineering in particular on fiber reinforced composites
- Expertise in polymer compounding
- Expertise in mould design
- Expertise in process and automation technology
- Expertise in contactless temperature measurement
- Expertise in polymer testing
- Expertise in economical and environmental assessment including safety

Equipment:

- Microwave equipment not multi-mode
- Compounder to modify resins
- Test facilities for testing polymers in particular mechanical testing and DSC
- Handling system with microwave adaption to cure 3-shaped geometries like a robot system
- Computer added tools for designing moulds
- Contactless temperature measurement equipment

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Additives to enhance the interaction of microwaves with resins	Report	T0 + 3
D2	Material investigation and testing of the sample	Report	T0 + 5
D3	3-D-Shape	Report	T0 + 8
D4	Mould	Report/ Design drawing	T0 + 9
D5	Environmental and economic assessments including safety	Report	T0 + 10

4. Topic value (€)

The total value of this work package shall not exceed:

150.000,00 €

[one hundred and fifty thousand Euro]

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

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-GRA-01-045	**Development of advanced Liquid Infusion Technology for Regional Wing panels structure: Numerical simulation of the process and validation through an innovative test bench.**	**Start date**	T_0 (**)
		End date	T_0 + 12 months

1. Short description

Task 1: Set up an advanced numerical simulation to study the liquid resin flow through stiffened wing panels preforms (see Figure 1, Figure 2 and Figure 3 in para 10). The model (referred to as "**LRI model**") shall contain the key process parameters.

The **LRI model** shall be used to set up the "Reference" LRI process, to identify possible causes of the slow down or non uniform distribution of resin flow that may cause dry spots, poor saturation of the preform, partially filled composite parts.

The **LRI model** shall be based on the mechanical/fluidynamic resin flow equations integrated with a thermochemistry model and viscosity model as appropriate.The **LRI model** shall allow to change the various paramenters and the viscosity models adopted. The initial issue of the **LRI model** shall be based on an agreed "Reference Resin System". The applicant will select and explain in the Proposal the methodology for verification and validation of the code before delivery to Topic Manager .

The model shall be utilized by the Topic Manager to support the final design of the resin infusion system overall architecture (Topic Manager task).

Task 2: Based on the results of the Task 1 and the results of the final design of the resin infusion system performed by the Topc Manager, the Applicant shall design and manufacture an innovative test bench including mechanical components (molds, fairing bars, auxiliary tools, templates, etc.). As a reference, see Figure 3.

The Topic Manager will supply interface informations with his equipment.

Task 3: The applicant shall support the Topic Manager for the final LRI model validation on the test bench.

The LRI System equipments (resin heating, ducts, resin distribution,…) are not part of the CfP tasks.

2. Introduction

Background

Within the "Low Weight Configuration" (LWC) Domain of the Green Regional Aircraft one main activity is the manufacturing of the Wing Large Panels for the Preparation of Ground Test Demonstration (WP 1.6.2).

The Liquid Resin Infusion (LRI) process is one of the most promising technologies as it should provide good properties within an acceptable cost range also reducing the manufacturing risk of large complex structure.

It consists in infusing the liquid resin in a pre-shaped dry fabric preform. The preforms (e.g. skin-stringers) are supported by specially shaped molds and fairing bars and positioned with special templates (see Figure 3). The resin is heated and injected into a vacuum bag using special means. The cure cycle results then in a fiber reinforced structure. (Other LRI schemes are also possible). Specific suction ports (to vacuum pump) are provided.

The LRI is alternative to other similar processes like the Resin Film Infusion (RFI) in which the resin is pre shaped in film sheets, interlayed between the fabric layers or placed between the mold and the preform; the Controlled Atmospheric Pressure Resin Infusion (CAPRI); the Resin Transfer Molding (RTM) and others. All the Infusion techniques compete with the well known and largely used pre-preg composite technologies.

The Topic Manager is currently manufacturing small panels using a LRI set up adequate for small and for medium size stiffened panels (approx 600x900 mm).

A more sophisticated mature and reliable Liquid Resin Infusion System will be needed for large stiffened panels (approx 1300x4000 mm); in fact due to the size and the thickness of the components a good Knowledge of the process physics is necessary, in order to optimize the different parameters and perform an optimized and innovative mold and tools design and manufacturing.

3. Interfaces to Integrated Technology Demonstrator (ITD)

The content of the present CfP fits in the Task 1.6.2-01, Design and Manufacturing preparation of the Wing Box Upper and lower composite panels. It requires multi-disciplinary competences and design capability (fluid dynamics, thermo-chemistry, composite materials cure processes, tools and equipments design , manufacturing and control). The "**LRI model**" shall be based on a commercial software and shall be provided to the Topic Manager together with an "LRI Model Description" document (template will be provided to the successful applicant) in which the idealization scheme, parameters definition, and other assumptions will be described in detail .An additional document "LRI Model Validation" shall be issued, in which validation procedure and results will be shown.

As far as tool design is concerned, the input/output geometrical models data exchange will be handled through standard formats (CATIA V5 and LRI Model native data).

4. Scope of the work

The Design of a composite part requires a multidisciplinary approach and a more stringent Concurrent Engineering (CE) methodology.

The Design and Manufacturing of of composite wing panels based on the new LRI technology, in addition to the CE approach, the standard structural tools (CATIA; NASTRAN/PATRAN) and Composite Design manuals, will require a mechanical/fluidynamic model, the **LRI model,** to study the liquid resin flow through stiffened wing panels preform and assist in panel and equipments and tools design:

- The **LRI model** shall be used by the Topic Manager to set up and optimize the LRI manufacturing process, to identify possible causes of the slow down or non uniform distribution of resin flow that may cause dry spots, poor saturation of the preform, partially filled composite parts.
- The **LRI model** shall be utilized by the Topic Manager to support the final design of the resin infusion system overall architecture (Topic Manager task).
- The **LRI model** will also support the definition of some critical design details (Topic Manager task).
- The **LRI model** shall be used by the Applicant as a support to perform the design and manufacture the test bench mechanical components (Task 2)

The work scope, in addition to the development and initial verification and validation of the **LRI model,** will include the design and manufacturing of the test bench mechanical components (such as molds, fairing bars, auxiliary tools, templates,..), considering, as appropriate, the results of the **LRI model.**

The Topic Manager will perform the final **LRI model** validation, including resin heating; resin distribution and injection; vacuum system set up; interfacing with the autoclave on the test bench.

Support to the Topic Manager by the successful Applicant to perform the final **RFI model** validation will be required. The applicant shall consider this (limited) activity in his Proposal.

5. Type of work

The work will require multidisciplinary competences:

- Manufacturing Process Simulation, through commercial software capable to simulate Mechanical/fluid dynamics laws, integrating thermo chemistry and viscosity models as appropriate. A parametric approach shall be used. It shall be possible to change the key process parameters and the different models.
- Design and manufacturing of Innovative Tools for the manufacturing of the panels. The tools shall consider the use of preforms (skin+ stringers) and the liquid resin injection system. (A scheme of the panels and of the LRI injection system is provided in chapter 5). CATIA models will be provided at a later stage.

Abbreviations & Definitions

CE	Concurrent Engineering
GRA	Green Regional Aircraft
ITD	Integrated Technology Demonstrator
LRI	Liquid Resin Infusion
LWC	Low Weight Configuration
WP	Work Package

6. Description of the Work

According to the objectives described in par. 1.2 and 1.3 , the activity will develop through several tasks, as described hereinafter. It is the responsibility of the successful Applicant to expand and detail the tasks in order to accomplish the overall scope of work:

a. Task1 (LRI model)

This task will include at least the following activities/outputs:

- ✓ Selection of the Resin and fiber (Topic Manager input, **only as reference.** Resin and fibers will be derived from **non proprietary data**)
- ✓ Identification of Resin characteristic parameters.
- ✓ Selection of viscosity models.
- ✓ Set up the physics of the LRI Process.
- ✓ Resin injection methodology and strategy (Panels layouts are provided by the Topic Manager; task to be harmonized with the Topic Manager).
- ✓ Numerical simulation model set up. The code shall be a commercial one and shall allow to change resin parameters, viscosity models and other characteristics.
- ✓ Verification and validation steps.
- ✓ "LRI Model Description" document.

b. Task 2 (Tools)

This task will include at least the following activities/outputs:

- ✓ Review panel design and the preform geometry (layouts provided by the Topic Manager) .
- ✓ Selection of Tools materials (trade off steel-composite-aluminum)

- ✓ Bonding Tools (main mold, auxiliary tools, e.g. suction ports (to vacuum) positioning tools, fairing bars, templates, input to the conceptual design and tools-preform geometry optimization considering the LRI method and equipments)
- ✓ Tools design (CATIA models)
- ✓ Tools manufacturing and control.

NOTE: the task shall consider the manufacturing of two set of (main) tools as two (different) panels shall be manufactured that is upper and lower wing panels, having, at this stage, different geometry (OML and stringers size and pitch).

c. Requirements

Sensitive information may be released at a later date to the successful Applicant. Final geometrical data will be released to the successful Applicant. Some basic information are provided in chapter 10.

d. Milestones

The following Main Milestones and activities are identified:

M1 (T_0 + 3 months):
a) Review of the **LRI model** progress

M2 (T_0 + 6 months):
a) Release of the **LRI model** with a basic description and draft user manual
b) Preliminary Design Review of the tools design

M3 (T_0 + 8 months)
a) Release of the LRI model User manual
b) Release of the LRI validation and verification Report
c) Release of LRI troubleshooting manual
d) Release of Bonding Tools Design
e) Release of the Bonding Tools

Review meetings to monitor on the work progress will be scheduled. On such occasions, recovery actions will be decided in case of delayed activities, in order to stay in the overall initial planning.

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

Due the technical complexity of the requested activity and the relevant tight schedule, the proven expertise and previous similar experience of the applicants in the concerned multi-disciplinary technological fields will be a key factor of selection.

The use of advanced computational tools for the process modeling is regarded as a paramount requirement to correctly address the physical phenomena involved.

A solid experience in designing and manufacturing of steel (or composite) tools for advanced composite components, to be tailored to this specific components, is also a key factor of selection

8. Major Deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	"Reference" Resin characteristic Parameters and Viscosity models	Report with "Reference" Resin data	T_0 + 2 months
D2	LRI numerical model (**LRI Model**)	Numerical simulation model based on the selected commercial code with a basic description.	T_0 + 6 months
D3	Tools preliminary design	Tools preliminary 3D CATIA models. The tools shall include the upper and lower skin molds, the preformed stringers fairing bars, the auxiliary tools, the positioning templates as necessary.	T_0 + 6 months
D4	LRI numerical model verification and validation	Report describing the methodology adopted to perform the model verification and validation and the related results.	T_0 + 8 months
D5	Release of the LRI model Description document manual	Complete Report describing the methodology and the steps performed to create the models for process simulation	T_0 + 8 months
D6	Tools design	Tools 3D and 2D Final CATIA models	T_0 + 8 months
D7	Tools delivery	Deliver a set of tools for upper and lower stiffened panels. The tools shall each have an Inspection Report.	T_0 + 8 months
D8	Support to Topic Manager	The Successful Applicant shall support the Topic Manager for the final LRI model validation on the test bench. A total of 300 h are considered adequate .	T_0 + 12 months

Table 1: Deliverable Description and Schedule

9. Topic value (€)

Budget:

330.000,00€
[three hundred thirty thousand Euro]

including all cost categories (personnel, material, computing, travels, reporting)

Funding: ranging from 50% to 75% of the budget, according the GRA Program rules.

10. Remarks

Preliminary Sketches of the Infusion System concept (taken from the literature) and of the upper and lower panels layout, main preliminary dimensions and main tooling concepts are provided to assist the applicants in the proposal preparation (see Figure 1, Figure 2 and Figure 3).

Final data and requirements will be provided to the successful Applicant only.

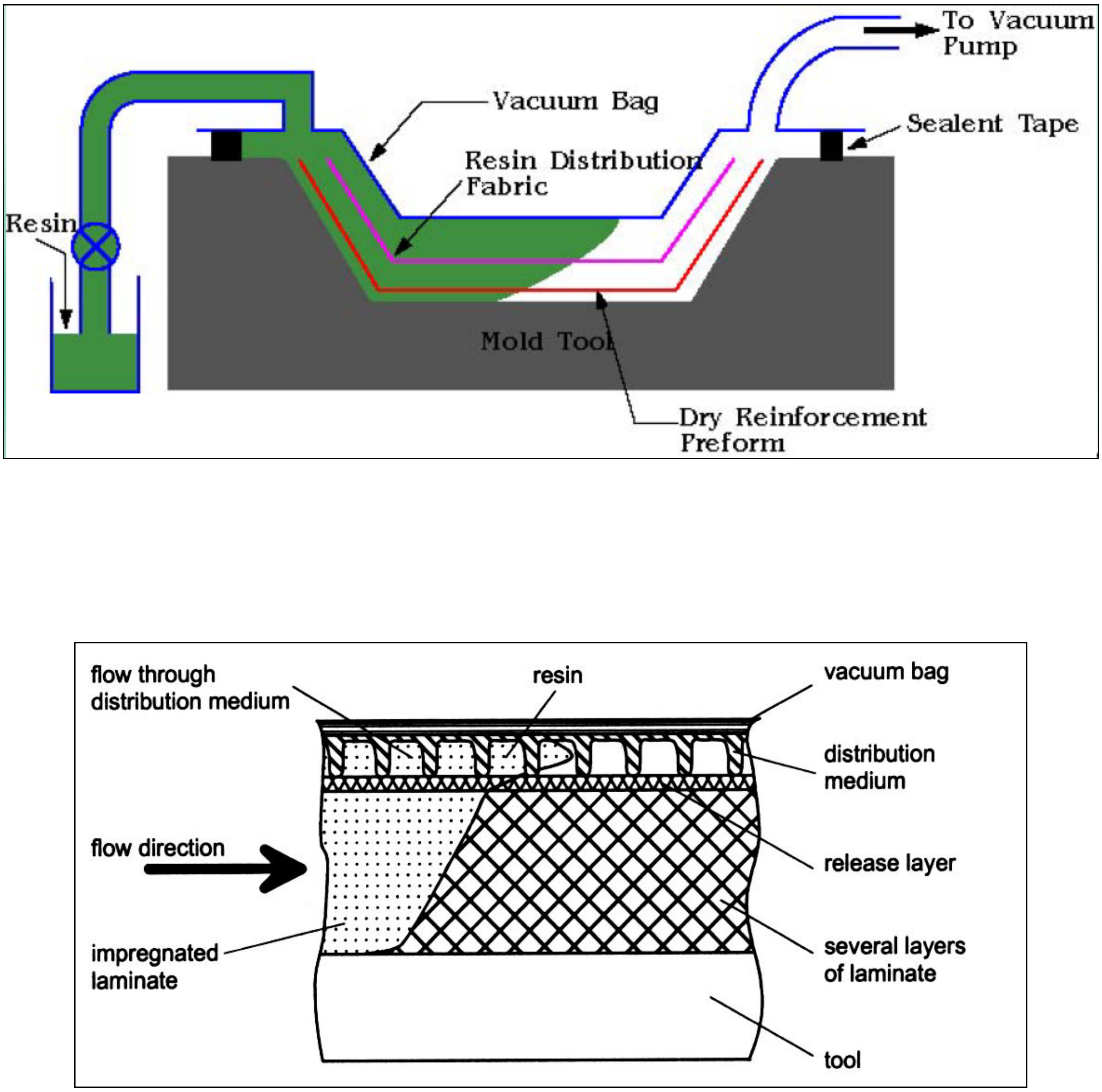


Figure 1: Infusion System Concept and Detail

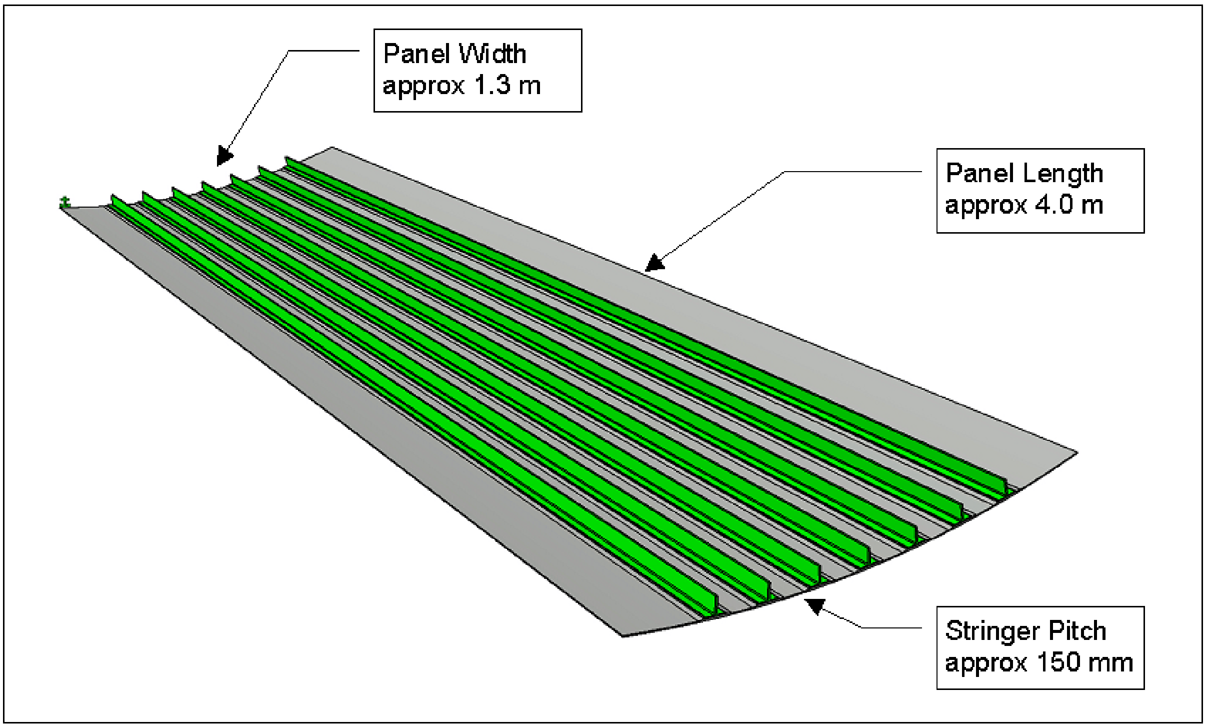


Figure 2: Typical Wing Skin Layout (Preliminary)

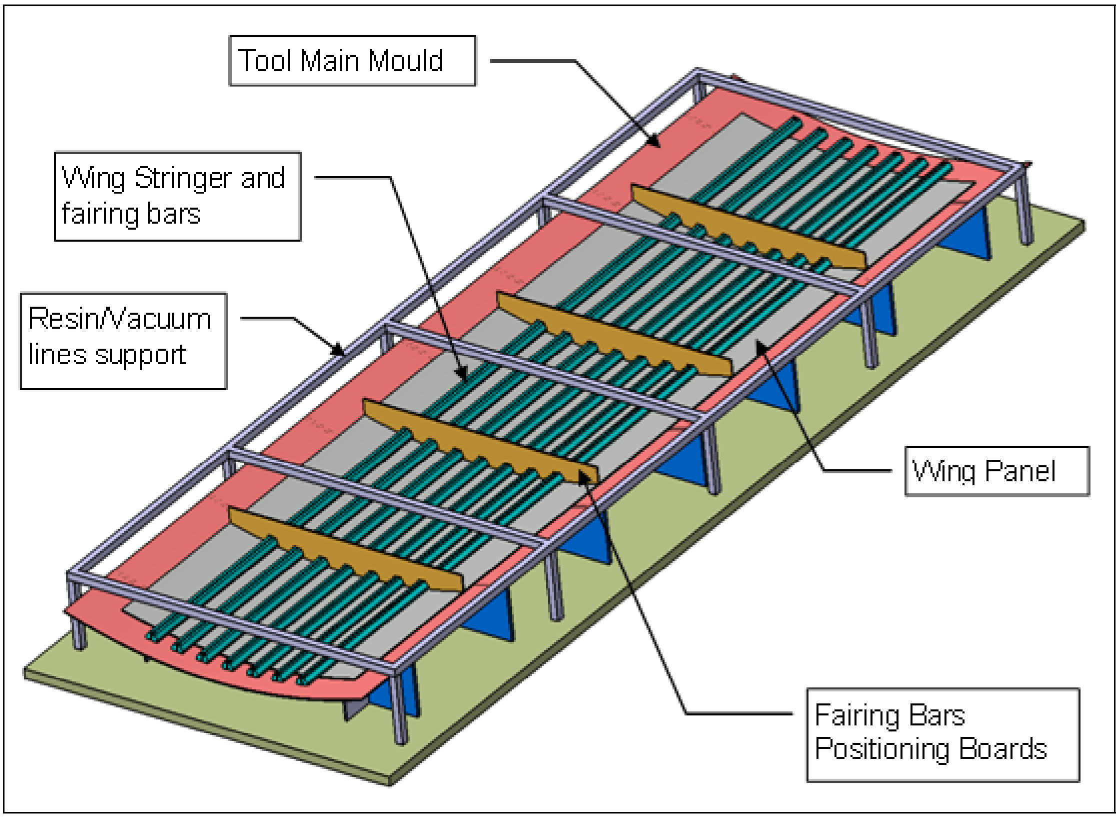


Figure 3: Wing Panel Tooling Concept (Preliminary)

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-GRA-01-046	**Collapsible tooling proposal for Aircraft nose fuselage & cockpit**	**Start date**	*T0*
		End date	*T0+15*

1. Topic Description

The subject of this CfP is to explore new tooling technologies applicable to future A/C nose fuselage and cockpit in the area of composite materials.

1.1 Introduction

The job to be done must enable the production a quick prototype of a curved panel and architecture representative of the stiffened skin conforming to a portion of the nose fuselage (cockpit). Skin lay-up and material should be a step forward the final configuration applicable to ground demonstrator and based on detailed design and experience handled within other working packages (i.e. Wp1.3.7 or Wp1.4.2).

1.2 Reference documents

None

1.3 Scope of work :

The activities to be carried out within this CfP will include several areas of expertise in order to develop innovative ideas to produce a practical tooling involved in nose fuselage (cockpit) composite materials "single shot" manufacturing.

In this context, three areas are expected being explored:

- Collapsible tooling
- Magnetic applications
- Automatic handling for demoulding/manipulation of composite parts

All studies must end in a tool demonstrator where all solutions can be implemented.

As a result of the research being carried, success should be demonstrated through the manufacturing of a "by the time" selected portion of nose fuselage (cockpit) that should consolidate "feasibility" with appropriate level of quality. Lack of quality should have correction potential through tooling design refinement and/or process improvement accounting for new ancillary material usage. Appropriate assessment on this respect must be supplied.

The detailed configuration of the structural component to be produced will be supplied by ITD

1.3.1 Collapsible concepts.

In a first approximation to the problem, new solutions are needed to AFP laminating and curing tools with collapsible requirements. The details of the concept of collapsibility will de defined throughout the process.

Detailed study will be needed before implementing new ideas to the tool. This should cover, theoretical reports and practical experiments with solid conclusions conforming practical deliverables.

1.3.2 Magnetic Applications

As a second part of the studies integrated in this CfP, new magnetic applications are to be researched. The use of magnets in tools involved in the manufacturing of composite parts and its behaviour at high temperatures (autoclave cycles) is an area that will be explored by the applicant.

Proposals will include the necessary studies and trials prior to final designs and applications in the laminating/curing tool.

1.3.3 Automatic manipulation

As a final part of the CfP, automatic devices such as robotic arms or intelligent revolving tools are to be designed by the applicant. This application should be capable of remoulding the part manufactured in the tools resulting of the previous studies and handle it by automatic means to an auxiliary position.

1.4 Design review

Description of all these key characteristics that should govern the product performance will be compiled into correspondent documentation whose design maturity will evolve through corresponding revision by ITD. In this context, continuous technical assistance and monitoring of the call evolution will be provided by the applicant. Different conceptual design and manufacturing alternatives will be subjected to trade-off assessment through the process.

1.5 Manufacturing trials

Design proposal must be consolidated into manufacturing trials of structural specimens to prove conceptual approaches. As far these trials can be accommodated in the overall CfP schedule, they should progressively combine proposed innovations until 1st Article had been produced.

Tooling, process or ancillary materials usage update, as required, will be done before a 2nd article manufacturing to improve quality and/or to solve pending issues.

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

Experience in composite design, manufacturing and NDT

Experience in tooling design

Use of CATIA V5R16 will also be mandatory for all designs (other versions on request)

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Design concepts	Document	T0+02
D2	Tooling Models	CATIA	T0+04
D3	First trials reports	Document	T0+06
D4	Tooling Manufacturing	Hardware	T0+08
D5	1st Article Manufacturing & Inspection	Hardware + Document	T0+12
D7	2nd Article Manufacturing & Inspection	Hardware + Document	T0+14
D8	Conclusion & Recommendations	Document	T0+15

4. Topic value (€)

Budget:
The total value of the proposed package shall not exceed

300.000,00€

[three hundred thousand Euro]

including all cost categories (personnel, computing, travels, etc.);
Funding: ranging from 50% to 75% of the budget

5. Remarks

The meetings for project monitoring will be held at Topic Manager plant. It is foreseen a meeting every three months.

Experience on the required subject must be referred by the applicant

1.5 x 1,5 x 1,5 m should be used to quote the size of the tooling demonstrator being proposed.

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-GRA-01-047	**Advanced light pressure bulkhead for a/c cockpit**	**Start date**	*T0*
		End date	*T0+18*

1. Topic Description

The essence of the job is to state the bases to come with a cheap but efficient manufacturing process based on LRI to produce a structurally efficient pressure bulkhead concept.

Justification should take place through the manufacturing of (approx 1200 x 1200 mm2) demonstrator and correspondent preliminary test of coupons extracted from one of the manufactured specimen. The job details are described within following points

1.1 Introduction

This work is allocated inside the WP 1.5 & 1.6 which is devoted to conceptual, detailed design and effective manufacturing of structural components with direct application to a global demonstrator.

1.2 Reference documents

None

1.3 Scope of work:

The current pressure bulkheads require a high manual task in the later assembly stage, because it needs stiffeners and profiles to be added to the final structure. Therefore, it is very interesting being able to get aeronautical composite parts that have a high integration level in its primary curing stage.

We look for the development of bulkheads based on infusion technologies by means of alternative processes different to the traditional closed moulding (RTM), as new infusion technologies that get competitive costs and features as in the pre-preg technologies.

It is also very important the development of structural tests for bulkhead made by means of RLI, based on low-cost tooling. We are looking for an optimization of the resin injection/transfer process for new resin systems, in order to obtain a good assembly of all the modular tooling, as well as an application of customised/preformed vacuum bags.

Moreover, it will be studied the potential enabling of the infusion as a matured technology for its potential future selection in the structures similar to the forward/dummy bulkhead (primary parts with structural responsibility), bearing in mind the objective of boosting the low cost process along the product development process.

1.4 Bulkhead design guidelines according to surrounding pressurized cockpit structure.

Along this task, typical concurrent engineering activities would be performed, detailing the potential modifications in the aeronautical structure together between all the related departments, as production and design departments. The goal is to achieve a common understanding regarding the set of requirements to be accomplished by the final product.

Description of all these key characteristics that should govern the product performance will be compiled into correspondent documentation whose design maturity will evolve through corresponding PDR & CDR faces of respective disciplines (element & tooling design). In this context, continuous technical assistance and monitoring of the call evolution will be provided by the applicant. Different conceptual design and manufacturing alternatives will be subjected to trade-off assessment through the process.

1.5 Acceptance criteria for quality control

Bearing in mind that main design drivers are covered in before point (i.e. stress requirements), the content of this task should deal with assessment of those aspects involving quality control for acceptance (i.e. allowable defects, dimensional tolerances including stiffeners position, surface roughness, porosity and any other aspect that can be considered essential regarding structural performance

Within this activity, technical sheets for inspection and checking of the demonstrator will be elaborated, defining attenuations, typical thicknesses of the part, and tolerances range of each control parameter.

1.6 Pre qualifying screening

All the coupons necessary for the structural tensile strength tests, interlaminar shear strength, fracture toughness and other critical mechanical properties which are compulsory for a correct definition of the pressure bulkhead configuration

1.7 Results report

Critical parameters survey and values study according to the prior qualifying sequence (Point 1.4) must be performed in this task.

1.8 Demonstrator manufacturing trials

It will be develop and obtained a real RLI bulkhead pressure structure that will be later structurally tested. The main stages of this activity will consist of: Prototyping,

Design, Tooling manufacturing and Pressure Bulkhead development. Along all these stages, an optimization of the resin injection into the part, an improvement of the modular tools integration, and a customized vacuum bag are currently considered the main challenges of the development process.

1.9 Non destructive Demonstrator Inspection.

A non destructive inspection of the pressure bulkhead will be carried out, and its corresponding quality control report will be issued.

1.10 Destructive testing of demonstrator detail & coupons

Depending on previous NDT results and some other design issues, a representative first article manufacturing can be subjected to some morphology or mechanical coupons test to solve potential concerns. It should be also considered the low energy behavioral check through the performance of impacts at specific locations. Appropriate RFT will be provided on this respect.

1.11 Feasibility and applicability to mass production

As a main benefit of this technological research, it must be pointed out that a higher industrial implementation of innovating *OoA (Out of Autoclave)* processes instead of the traditional high cost processes. Otherwise this part configuration would be valid for high structural performance (Forward bulkhead and integrated frames).

Another great profit will be the saving in the product development and in the recurrent costs in futures aeronautical structures.

The successful development of this technology based on the OoA process concept, would suppose a large energy saving, because it would not be needed the autoclave oven (this process means about 20-30 % of the composite part global cost), moreover it implies a more respectful manufacturing process with the environment, because of the reduction in the tooling and materials expenses.

- Trade off on existing market (aeronautics & industrial)
- Future trends

2. Schedule, milestones and deliverables

a) Design phase (T0+4
b) Tooling manufacturing (T0+10)
c) Specimen manufacturing & inspection (T0+14)
d) Testing & reporting (T0+18)

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

Experience in composite design, manufacturing and NDT (aero structures)
High expertise in mature and advanced infusion
High expertise in innovative tooling design
Experience in CFRP coupons laminates testing

4. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Design Models	CATIA	T0+03
D2	Tooling Models	CATIA	T0+04
D3	Tooling Manufacturing	Hardware	T0+10
D4	Specimen Manufacturing + Inspection (3)	Hardware	T0+14
D5	Manufacturing report	Document	T0+14
D6	Test results	Document	T0+18
D7	Conclusion & Recommendations	Document	T0+18

5. Topic value (€)

Budget:
The total value of the proposed package shall not exceed

320.000,00€

[three hundred twenty thousand Euro]

including all cost categories (personnel, computing, travels, etc.);

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

6. Remarks

The meetings for project monitoring will be held at Topic Manager plant. It is foreseen a meeting every three months.

Experience on the required subject must be referred by the applicant

Clean Sky Joint Undertaking
JTI-CS-2012-01-GRA-01-048

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-GRA-01-048	**Design V&V of a self sensing Curved composite panel to predict/control damage evolution in real load condition**	**Start date**	*T0*
		End date	*T0+30*

1. Topic Description

Short description: JTI GRA aims to address low weight structures using a built-in real-time structural health monitoring (SHM) system. Unlike traditional NDE systems, the SHM system is designed to apply to a specific structure with a built-in network of sensors and actuators. Especially for composite aircraft structures where the influence of fatigue is low, this technique could potentially be economical and result in weight reduction of the structure, higher safety and reduced inspection time for damage identification. The proposed technique can also be applied for hybrid and metallic structures. An optimisation technique will be applied to find the optimum sensor position for damage detection for all possible impact scenarios on the full scale component (top Fuselage panel). All possible load events (hail, drop tool) and failure mode have to be considered in the optimisation analysis. This is necessary in order to build a valid alternative method to conventional NDTs (for a certain safety level). As a consequence the aim of this work is to set test procedure for the flight test to collect SHM data and to compare experimental/predicted value. The test must consist of the pristine in flight test, impact on the panel with a drop test (under, over and between the stringers from outside and inside panel) and multiple impacts on the panel (hail). The sensor data from the tests will be used for impact identification. SHM data collection needs to be done as well for detecting damage caused by the impact tests by actuating/sensing methods

1.1 Introduction

Damage in composite materials can lead to disastrous failures if they are not detected and fixed on time. A wide variety of damage modes in composites, such as delamination and fibre breakage introduced by impact, is difficult to be detected by conventional methods.

Structural Health Monitoring (SHM) provides a system with the ability to detect and interpret adverse changes in a structure even though the structure is in service. SHM systems can reduce the risk of the catastrophic failures, prolong the lifespan of the structures and reduce the cost of inspections. A number of methods have been proposed for damage detection based on comparing signals to baseline recorded from the undamaged structure. Lamb wave based diagnosis method is one of the most effective techniques in plate-like structures due to its sensitivity to small defects.

1.1.1 Background

The proposed work fits in the three work packages of GRA LWC “Enabling Technologies for Design”, “Enabling Technologies for Maintenance” and “LWC Definition of Demonstrator”. Obtaining some information about the intensity of an impact and its location on aircraft panels will help estimating the severity of possible damage due to the impact and subsequent actions. Furthermore, the predictability of impacts decrease uncertainties associated with loading conditions on a structure and therefore would result in less conservative design and as a result weight reduction. In SHM, the techniques that are used to identify impacts are often called passive sensing techniques in the sense that the SHM system only registers the guided waves generated by the impact. There are methods to identify the impact (find its intensity and location) by using the recorded guided waves. Among them, the ones that have been applied to rather complex panels are transfer function based and those using Artificial Neural Networks (ANN). For both, it is necessary to prepare a large number of known inputs (impact load and location) and outputs (sensor signals) to find their unknowns (training procedure). However, the ANN has been used in more studies due probably to the fact that it is a well-developed numerical methodology for representing nonlinear systems, such as aircraft panels. Nonetheless, this method has not been fully exploited for large aircraft panels under loading conditions.

In the active sensing SHM technique, on the other hand, actuators are employed as well as sensors. Actuators generate guided waves in the thin-walled structure (Lamb waves) and after travelling through the structure they are received by sensors. When there is a change in the state of the structure, such as damage, the received sensor signals change in comparison to the baseline signals, depending on the size and severity of the damage, excitation frequency, sensor/actuator pattern and distance of the sensor from the transducers network. Depending on the excitation frequency, Lamb waves can travel long distances without being significantly dispersed and therefore are effective for detecting distal damages.

Dispersion and attenuation of Lamb waves are two important properties, which are related. Dispersion is change in wave velocity with respect to frequency and attenuation is decrease in the wave amplitude with respect to the travelled distance. Increased dispersion causes higher attenuation and vice versa. In curved panels, the phase velocity is higher compared to flat panels, which will slightly increase the dispersion and attenuation of Lamb waves. This may imply that for similar excitation conditions, the Lamb wave SHM method can detect farther damages in flat panels compared to curved panels. The excitation modes will also be different in curved panels in comparison to flat ones.

Another factor for applying the active sensing technique to in-flight panel is that a good baseline signal (pristine signal) must be available. This baseline signal will vary under different load and vibration condition. The challenge will be to be able to record the pristine signal during different load scenarios and to be able to compare it with a damage scatter signal obtained under the same load conditions.

Despite all the advantages of the Lamb wave based damage detection method, there are a few works on its application to aircraft composite panels. These works have been able to detect the damage location to some extent but still much work has to be done to estimate size and severity of damage.

1.1.2 Interfaces to ITD

The details of the integration of the developed module into the GRA LWC platform will be defined together with the successful applicant.

1.2 Reference documents NA

1.3 Scope of work: In this work, it is expected that methodologies to predict/control damage evolution will be developed for a curved composite panel subjected to real load conditions. The developed computational tools should be able to model an impact event on a sensorised curved composite panel and to detect impact force and location. The transducer configuration must be optimised to allow for effective detection of impact and subsequent damage. Impact force detection and location is carried out by passive sensing. Active sensing is applied to first verify the existence of damage and to characterize it. In previous JTI projects such as SMASH, non-destructive evaluations of composite stiffened panels were developed for a simple stiffened composite panel. It has been demonstrated in SMASH project that the developed methodologies were capable of successfully performing passive and active sensing. However, the developed methodologies were applied and tested on a simple stiffened panel. The aim of this call is to extend such methodologies to more complicated panels under real load conditions. There is a significant issue with regards to up scaling the methodologies to take into account curvature of the panel as well as real load conditions (fatigue, hail, storm, etc). In addition the up scaled methodologies are required to be suitable for analysis of large size panels involving 10's of millions of degrees of freedom. The computational methodologies developed must include accurate modelling of curved composite panel, including robust modelling of advanced composites (woven composites).

The technologies that will be accounted for in passive sensing are fibre optic (FBG) and piezoelectric (PZT) sensors. PZT transducers are often a very attractive choice since they are capable of both sensing and actuating. They can be used in passive sensing to record strains for impact detection. PZTs act as both actuators (actuating Lamb waves) and sensors in active sensing to characterize damage. PZT transducers can be used on their own or in combination with other technologies to form a hybrid system (PZT actuator/FBG sensor).The SHM approaches which will be applied in passive sensing include Guided Ultrasonic Wave Propagation (GUWP) and Electro-Mechanical Impedance Method (EMI). Another advantage of PZT transducers is that they can be used as self-diagnostic sensors. Using EMI measures of the sensors a self-diagnostic survey of the transducers can be carried out prior to their application in active or passive sensing to detect the faulty sensors which could lead to incorrect diagnosis. The established code will be used for generating significant data which will be used in developing metamodels for damage identification. Moreover, statistical analysis of the structure will be carried to evaluate the Probability of Detection (PoD) and the Probability of False Alarm (PoFA) for the methodologies in question.

The code architecture can be described as:

- Computational tools for passive sensing (impact force magnitude and location detection)

- Computational tools for active sensing (damage detection and characterisation)
- Computational tool for effective transducer positions for design of self-diagnostic structure

It should be mentioned that all the codes should be in compliance with Alenia Aeronautica information technology infrastructure standards.

1.4 Type of work: The type of work to be performed is the modelling and simulations using FEM codes for both Passive and Active sensing. SMART FE will be integrated with the FE to carry out the actuating and sensing in the damage characterisation code. The panel which will be analysed in this project is of size 5m x 1.7 m radius 4.5 m which is very large compared to the composite stiffened panel used previously in JTI projects such as SMASH and MAXIMUS (approximately 2m x 1.1m). For Lamb wave propagation analysis the plate must be meshed very fine. This will lead to computationally expensive simulations. For example for impact simulation, where not so fine mesh is needed in comparison to Lamb wave propagation, for a panel of 5m x 1.7 m approximately the number of degrees of freedom are 21 000 000. For the same panel if Lamb wave based damage characterisation algorithm is applied, the number of degrees of freedom increases to 30 000 000. This is just to stress out how much computational power is necessary. Moreover impact simulations needs to be done with different size and velocity of impactor at different locations to cover the entire panel. The energy levels corresponding to each impact scenario is as well described. When modelling the in flight scenario, the additional noise which will affect the data should be considered in the analysis. Attention must also be paid to the fact that the flying sensorised panel will have different baseline signals in different load and vibration scenarios (different manoeuvres). This is of high importance when the damage scattered signal will be compared to the pristine signal for detecting and identifying damage. Thus a good load history of the panel during the flight must be available.

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

The participant should have knowledge and experience in large scale FE analysis, in specific in impact simulations, dynamic analysis, damage and fracture analysis and high level programing languages for developing interactive and open environments which are able to interact The applicants should have experience from participation in international research projects.

3. Major deliverables and schedule

Deliverable	Title	Due date	Deliverable
D 1.1	Report on adopted methodologies for developed for impact force magnitude and location	Month 6	D 1.1
D 1.2	Software code module, source code and documentation for the developed methodologies in D1.1	Month 9	D 1.2
D 2.1	Report on adopted methodologies for damage detection, identification and characterisation	Month 14	D 2.1
D 2.2	Report on self-diagnostic methodologies of the curved composite panel	Month 16	D 2.2
D 2.3	Software code module, source code and documentation for the developed methodologies in D2.1	Month 18	D 2.3
D 3.1	Report on methodologies developed for effective positioning of sensors and actuators	Month 22	D 3.1
D 3.2	Software code module, source code and documentation for the developed methodologies in D2.1	Month 24	D 3.2
D 4.1	Report on statistical analysis of the developed methodologies for impact force detection	Month 30	D 4.1
D 4.2	Report on statistical analysis and probability of false alarm of the developed methodologies for damage detection	Month 30	D 4.2

4.

5. Topic value (€)

Budget:
The total value of the proposed package shall not exceed

400.000,00€

[four hundred thousand Euro]

including all cost categories (personnel, computing, travels, etc.);

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

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-GRA-01-049	"Optimal tooling system design for large composite parts"	End date	T_0 + 12
		Start date	T_0

1. Topic Description

1.1 – Scope of work

The contractor shall define all the necessary steps to complete the design and manufacture of a large tool for a composite complex structural part (representative of a fuselage stiffened section / panel with co-cured stiffeners - approximately 2m in length by 1m in width, based on the composite part structure that will be defined by Topic Manager).

The contractor undertakes responsibility to the design and manufacture the final tool, based on the composite structural part (fuselage stiffened section / panel) that will be defined by the Topic manager. The geometrical complexity of the final manufactured composite part, should be a part with double curvature and co-cured stiffening elements. The stiffening elements shall be of both an "open" (typically "Z" type) and a "closed" (typically "Ω" type) cross section. A typical radius of curvature should range from 1.5m to 2m.

The tool design shall take into account the following requirements:

- Capability for achieving high accuracy typical of aerospace components
- High Rigidity of tool
- Ability to withstand high temperatures / pressures without ruining the part under construction (Typical autoclave cycle conditions: 180°C & 7 bar pressure)
- Matching coefficient of the tool to the composite part material (typically carbon fiber epoxy parts → Low CTE)
- Durable (last for many cycles – typically 500 autoclave cycles, ability to withstand normal wear & tear)
- Minimal weight resulting in minimal thermal mass to allow fast heating / cooling cycles
- Provision for easy transportation / handling in a standard composites facility environment (i.e. fork lifts, cranes, wheels etc)
- Provision for easy access in areas of the tool difficult to reach (i.e. centre of the tool)
- Integration of accessories for easy demoulding of part from tool (i.e. air-pressure assisted, removable parts in the tool etc)

Optionally the following requirements are preferable:

- Capabilities to do easy modifications on the tool
- Capabilities to do easy repairs on the tool

The tool construction should be metallic with a material complying with the above requirements.

The tool should also contain all necessary parts / configuration to allow for the co-curing of stiffener elements in the panels (in various configurations: typical cross sections "Ω","Z")

The tool should comply with all modern lay-up (manual or automated) configuration techniques for pre-preg autoclave curing (integration of necessary accessories for vacuum/ laser projection equipment / silicone vacuum bagging etc)

1.2 – Reference documents

Aerospace Engineering and Manufacturing, 10 Nov. 2010

Zhu, Q., Geubelle, P. H., Li, M., Tucker, C. L., III, "Dimensional accuracy of thermoset composites: simulation of process-induced residual stresses", Journal of Composites Materials, vol. 35, no. 24, pp 2171-2205, 2001

Manufacturing Engineering, April 2010 Vol. 144 No. 4

1.3 – Introduction

1.3.1 - Background

An important aspect of composite fabrication for aircraft parts is the capability to manufacture increasingly larger components. As production scales up, more-efficient manufacturing becomes increasingly important. An important step to that efficiency is tooling for composites.

A factor that has been clearly identified as playing a key role in process induced stress development and deformations in fiber reinforced composite parts during autoclave curing is the effect of tooling. The thermal and mechanical properties of the tooling and the mechanical interaction between composite part and tooling will influence the curing process; the effect is complicated by geometrical features of the part. The mismatch between coefficients of thermal expansion (CTE) of the composite part and tooling has been identified as an important contributor to process induced residual stresses developed during autoclave manufacturing

The factors that are responsible for composite part deformation (warpage and spring-in / out) need to be evaluated in order to identify the optimum values that would ensure the best geometrical and dimensional stability of the final part.

1.3.2 – Interfaces to ITD

The work is integrated within the WP 1.5.2 & 1.6.2 activities since one of its main objectives is the design and fabrication of a stiffened section / panel representative for fuselage for the ground demonstrator

1.4 - Activity Description

The final composite part configuration will be provided by Topic Manager (CAD models / layup configuration will be provided).

The contractor is responsible for the following tasks:

T1. The definition of the tooling basic configuration for the production of the final composite part by detailed identification of the criteria for tool configuration selection. This includes:

- Backing structure design (typical eggcrate / frame type)
- Tool face design (including all necessary details typically used in modern lay-up configuration techniques for pre-preg autoclave curing i.e. laser projection assisted lay-up)
- Integration of accessories (secondary tools: metallic or elastomeric / pressure pads etc.) necessary for co-curing of stiffening elements
- A detailed review list of alternative potential tooling material & related properties with advantages / disadvantages and related costs (row material / manufacturing) should be included.
- Detailed study of the tool concept definition (step by step) taking into account the specifications of final composite part. This study should include analysis of criteria for tool configuration and related materials selection

The backing structure should be connected with the tool face by such means that the thermal deformations from the backing structure are not transferred to the corresponding tool face. Also provision for minor adjustments of the tool face in relation to the backing structure should be available.

T2. Simulation by F.E.M. of final composite part springback / warpage by appropriate methodologies taking into account the forseen curing conditions in autoclave and part configuration / layup. Detailed final F.E.M models should be provided (preferably Patran / Nastran format) or in an open / neutral format to be imported in Patran / Nastran.

T3. Simulation by F.E.M. of tooling thermal behaviour and adaptation of final tool face design based on part springback and tooling thermal simulation, in order to minimise geometrical descrepancies between the “as designed” / “as manufactured” final composite part. Detailed final F.E.M models should be provided (preferably Patran / Nastran) or in an open / neutral format to be imported in Patran / Nastran.

T4. Design and manufacturing of the final complete tool structure (including all necessary integration accessories / secondary tools for the manufacturing of the stiffening elements, backing structure and tool face) based on the simutated behaviour. Detailed CAD models / drawings of the final tool should be provided (preferably CATIA models) or in an open / neutral format (i.e stp, iges) to be imported in CATIA

T5. Quality control on the final manufactured tool structure. This should include all critical measurements on the tool and accessories.

T6. Detailed cost analysis for the design and manufacturing of the tool

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

Expertise in tooling design and manufacturing (multi-part tooling) for aerospace quality composite parts.

Expertise in performing thermo-mechanical simulation of metallic and composite parts

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Tool basic configuration / design	Definition of tool basic elements (backing structure / tool face, accessories for lay-up assistance, accessories for inserts integration). Identification of criteria for tool configuration selection	T0 + 2
D2	Simulation of final composite part springback	Simulation of composite part thermal / lay-up configuration induced deformations	T0 + 3
D3	Simulation of tooling thermal behaviour and adaptation of final tool face design	Final tool design configuration based on composite part & tool thermal / lay-up configuration deformations	T0 + 5
D4	Design and manufacturing of final complete tool structure (including all necessary accessories)	Tool structure design and manufacture	T0 + 11
D5	Quality control documents of the final manufactured tool structure	Full documentation, with cad models of tool parts	T0 + 12
D6	Cost analysis	Report on cost analysis for designing and manufacturing of the tool	T0 + 12

4. Topic value (€)

Budget:
The total value of the proposed package shall not exceed

300.000,00€

[three hundred thousand Euro]

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

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-GRA-02-019	**Advanced, high aspect ratio Transonic Laminar Wing for Regional Aircraft with Load Control & Alleviation devices**	**Start date**	T_0 (**)
		End date	T_0 + 24 months
Technological Optimisation and Experimental Validation through an Innovative WT Model matching the full-size wing flexibility			

1. Topic Description

Short description

On the basis of a Natural Laminar Flow (NLF) wing aerodynamic design, aero-elastic model and Load Control & Alleviation (LC&A) concepts provided as input data, optimisation and development of wing control devices aimed at achieving optimal loads distributions, in order to enhance aerodynamic efficiency in climb and other off-design conditions and also alleviate wing bending moment.

Design and manufacturing of a flexible WT wing model representative of the full-size wing aerodynamic performance and structural response in cruise and off-design conditions, as predicted by computational analyses.

WT tests at transonic speed and high Reynolds number, in order to validate in a representative environment at cruise, climb and over-speed off-design conditions:

a) NLF wing design (namely laminar flow extent) considering the nominal aerodynamic shape and also simulating the presence of surface irregularities (steps/gaps and distributed roughness);

b) wing control devices effectiveness in getting reduced aerodynamic static loads and/or drag in both cruise and off-design conditions.

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 design (aerodynamics, loads, aero-elasticity, structures) and experimental validation through WT testing of a NLF wing design 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). 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 / development of LC&A concepts applied to a high aspect ratio transonic NLF wing configuration.

ii) Experimental validation through WT aerodynamic testing at high-speed (up to Mach ≈ 0.8) and high Reynolds numbers, close to those expected in flight (Re ≈ 20 million), of the NLF wing design (namely laminar flow extent) and of LC&A devices effectiveness in cruise and off-design conditions. Aims of such tests is to assess the viability of the whole laminar wing concept, thus validating the wing aerodynamic design coupled with the wing structural response under loads, also considering the wing manufacturing / technological standard. Therefore a flexible WT model of the wing will have to be manufactured so as to reproduce not only the wing external shaping but also its expected stiffness and surface irregularities (steps, gaps and distributed roughness).

1.3 Type of work

Wing aerodynamic (CFD) analysis, structural (FEM) modelling, structural/aero-mechanics analysis (aerodynamic and loads), static aero-elasticity analyses, mechanical design, wind tunnel testing and experimental data acquisition.

1.4 Abbreviations & Definitions

A/C	Aircraft
CAD	Computer Aided Design
CDR	Critical Design Review
CFD	Computational Fluid Dynamics
CfP	Call for Proposals
CSM	Computational Structural Mechanics
D&M	Design & Manufacturing
FEM	Finite Element Model
GRA	Green Regional Aircraft
HW	Hardware
ITD	Integrated Technology Demonstrator
LC&A	Load Control & Alleviation
LNC	Low Noise Configuration
Mach	Mach number
NLF	Natural Laminar Flow
PDR	Preliminary Design Review
PSP	Pressure Sensitive Paint
Re	Reynolds number
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 / Development of Load Control & Alleviation concepts

Input: Full-scale laminar wing geometry, Aero-elastic wing model, initial configurations of LC&A devices from the concepts under study within the GRA ITD, technical specification for WT testing.

Task 1.1

The first phase of the required work will be dealing with a CFD based 3D aerodynamic optimisation of LC&A devices configurations in several flow conditions. The objective is to find optimal loads distributions, in order to enhance aerodynamic efficiency in climb and other off-design conditions and also alleviate wing bending moment, preserving laminar flow extent. 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.

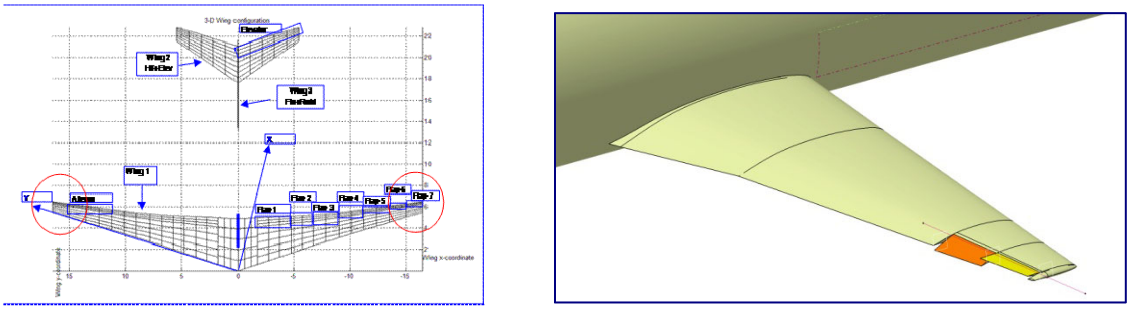


Figure 1 – Sketch of possible LC&A devices

The Applicant should optimize these configurations for several flow conditions without modifying neither the wing aerodynamic shape nor the FEM model, but taking account of the wing aero-elastic behaviour and preserving laminar flow. The flow conditions are expected to range between Mach number [0.6 - 0.8], incidence angle [-2.5 / +2.5 deg] and Reynolds number [15 - 21] 10^6.

Task 1.2

The Applicant should propose and develop alternative device(s) for LC&A, still optimised in terms of position, sizing and setting for aerodynamic efficiency improvement and bending moment reduction, at the same flow conditions as the ones considered in Task 1.1 and, hence, compare relevant performances with those achieved through initial LC&A devices 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.

<u>Outputs</u>:

a) Wing geometry with optimised LC&A devices (CAD models, drawings) - **Deliverable D1.1**

b) Assessment of performances of optimised LC&A devices - **Deliverable D1.2**;

c) Wing geometry with new LC&A devices as proposed by the Applicant (CAD models, drawings) - **Deliverable D1.3**;

d) Assessment of performances of new LC&A devices - **Deliverable D1.4**

1.5.2 WP 2 – Wing WT Model Mechanical Design & Manufacturing

<u>Inputs</u>:

Full-scale laminar wing geometry, aero-elastic wing model, selected LC&A devices from WP1, technical specification for WT testing.

The full-size aerodynamic / aero-elastic laminar wing equipped with the selected LC&A devices (from WP 1) has to be scaled down to the wing tunnel model size ensuring that the wing model deformation be representative of the actual wing deformation at specified flow conditions. In this respect, it has to be remarked that, in order to get higher Reynolds numbers, it might be necessary to consider a model reproducing the outboard part only of the wing (see figure 2). Mechanical design and stress analysis for the estimation of the wing model deformation 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, piping etc.), may strongly affect the mass distribution and inertia. In doing so, it has to be taken into account, in particular, that the wing model has to house all equipment and devices related to LC&A tests. Wing movable surfaces, in fact, should be remotely controlled and respective deflection angles recorded.

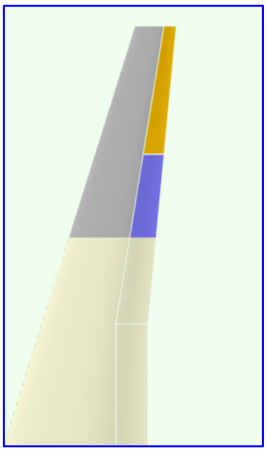


Figure 2 – Sketch of wing and of respective outboard region possibly to be considered for WTT.

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. A number of 15-20 unsteady pressure sensors, such as Kulites, able to gather unsteady pressure variation will be installed on the model to complement boundary layer transition assessment.

The Applicant shall propose a suitable way to integrate the probes (psi, Kulites) with minimal flow disturbance.

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. Other accelerometers will be placed on LC&A devices to gather possible buffeting.

All the constraints regarding the surface refinement, gaps and steps for natural laminar flow tests have to be considered during the mechanical design and the manufacturing phase.

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

1) Natural laminar flow extent on the clean wing (nominal shape)

2) Two steps/gaps configurations scaled from those foreseen to be present on the full-size wing due to its specific manufacturing technologies

3) Two contaminants configurations representative of average/severe insects smashing on the leading edge

4) Load Control & Alleviation devices effectiveness

Outputs:

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

b) Wing WT model design and stress analysis report – **Deliverable D2.2**

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

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

1.5.3 WP 3 - Static and dynamic ground vibration tests

Input:

Wing WT model (HW), Wing WT model aero-elasticity analyses (from WP2)

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

- Static vibration tests in order to check the static deformation. The results will be compared to CFD computations.
- Dynamic vibration tests to measure the natural frequencies of the model.

Outputs:

a) Wing WT model static vibration tests report – **Deliverable D3.1**

b) Wing WT model dynamic vibration tests report - **Deliverable D3.2**

1.5.4 WP 4 – Wind Tunnel Tests

Input:

Wing WT model (HW) from WP2

The wind tunnel test campaign will be performed at high speed regime (Mach range ≈ 0.6 - 0.8) and high Reynolds numbers close to those expected in-flight (Re ≈ 20 million) in order to validate in a representative environment at transonic cruise and off-design conditions (climbing, over-speed) both the laminar wing design and the LC&A concepts performance, matching the aero-elastic behaviour of the actual wing. The concerned tests will be split into following phases:

Phase #1

Assessment of laminar boundary layer extent at Reynolds and Mach numbers of interest for Regional Aircraft reproducing also:

- the airframe deformation
- manufacturing peculiarities (steps and gaps)
- presence of contaminants (due, for instance, to insects smashing)

Phase #2

Assessment of the effects that innovative trailing edge devices have in reducing induced drag and the wing root bending moment.

Following measurements are envisaged:

- Laminar/turbulent transition;
- Steady and unsteady pressure measurements;
- Aerodynamic forces balance measurements to gather lift, drag, pitching moment and roll (bending) moment;
- Aerodynamic loads distributions (preference is given to advanced pressure plotting techniques such as PSP);
- LC&A movable surfaces hinge moment measurements;

- Wing model static deformation: measurements of vertical displacements (orthogonal to the wing plane), bending and twist rotations pertinent to at least 4 (four) wing spanwise sections. Monitoring of wing displacements also in non-steady conditions is highly desired.
- Wing tip accelerations to detect possible occurrence of dynamic aero-elastic instability phenomena.

Concerning the laminar/turbulent transition measurements it is expected that well validate techniques such as thermal imaging will be used.

Furthermore, during LC&A devices performance tests (phase #2) remote monitoring and control of wing movables deflections is thought necessary.

Outputs:

a) WT tests plan (**Deliverable D4.1**)
b) WT tests report (**Deliverable D4.2**)

1.5.5 WP5 - Assessment of Project Results

Inputs:

a) Theoretical evaluation at cruise and off-design conditions of: i) NLF wing design, ii) flexible wing structural response, LC&A devices aerodynamic 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 5.1**

b) Overall assessment of project results – **Deliverable D5.2**

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 concepts

M2 (T_0 + 9 months):
WT Model Preliminary Design Review

M3 (T_0 + 12 months):
WT Model Design

M4 (T_0 + 16 months):
WT Model manufacturing Acceptance

M5 (T_0 + 18 months)
Static and dynamic grounded vibration tests

M6 (T_0 + 19 months)
Wind Tunnel Test Plan

M7 (T_0 + 21 months)
Wind Tunnel Tests Results

M8 (T_0 + 24 months)
Overall assessment of project 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 laminar wing models. In particular, the characteristics (flow quality and experimental measurements techniques) of the wind tunnel have to ensure highly-accurate testing of laminar flow extent at high-speed and high Reynolds number conditions 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	**Wing geometry with optimised LC&A devices configurations (location, sizing & setting)**	**CAD models, drawings** **1st group of LC&A concepts derived from those given in input by the GRA member**	T_0 + 3 months
D1.2	**Assessment of performances of optimised LC&A devices (first group)**	**REPORT**	T_0 + 3 months
D1.3	**Wing geometry with new LC&A devices (as proposed by the Applicant)**	**CAD models, drawings** **2nd group of LC&A concepts as proposed by the Applicant**	T_0 + 7 months
D1.4	**Assessment of performances of new LC&A devices, and best concept(s) down-selection**	**REPORT** **Comparison with the performances of the 1st group of LC&A devices and choice of technical solutions for WTT**	T_0 + 7 months
D2.1	**Wing WT model design**	**CAD and FEM models**	T_0 + 12 months
D2.2	**Wing WT model design description and stress analysis**	**REPORT**	T_0 + 12 months
D2.3	**Wing WT model**	**HW**	T_0 + 16 months
D2.4	**Wing WT model manufacturing description**	**REPORT** **Model Acceptance**	T_0 + 16 months
D3.1	**Wing WT model static vibration testing**	**REPORT**	T_0 + 18 months
D3.2	**Wing WT model dynamic vibration testing**	**REPORT**	T_0 + 18 months
D4.1	**WT tests plan**	**REPORT**	T_0 + 19 months
D4.2	**WT testing**	**TEST REPORT**	T_0 + 21 months
D5.1	**Analysis of WT tests results**	**REPORT**	T_0 + 22 months
D5.2	**Overall assessment of project achievements**	**REPORT**	T_0 + 24 months

4. Topic value (€)

Budget:

4,300,000 €

(4 million, three 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 experimental validation of Natural Laminar Flow and LC&A integrated technologies through a single WT wing flexible model, reproducing the actual wing deformation due to the structural response under aerodynamic 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 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.

Clean Sky Joint Undertaking
JTI-CS-2012-01-GRA-03-009

Topic description

CfP topic number	Title		
JTI-CS-2012-01-GRA-03-009	**Advanced Flight Control System –** Design, Development and Manufacturing of an Electro Mechanical Actuator with associated Electronic Control Unit and dedicated Test Bench.	**Start date**	T0
		End date	T0 + M16

Abbreviation List

AC	Alternate Current
A/C	Aircraft
AEA	All Electric Aircraft
AFCS	Advanced Flight Control System
ATR	Acceptance Test Report
CBIT	Continuous Built In Test
CfP	Call for Proposal
DC	Direct Current
DDP	Declaration of Design and Performance
ECU	Electronic Control Unit
E-EM	Electrical Energy Management
EMA	Electro-Mechanical Actuator
EMACS	Electro-Mechanical Actuator Command System
EMC	Electro Magnetic Compatibility
EMI	Electro Magnetic Interference
EPGDS	Electrical Power Generation and Distribution System
FCC	Flight Control Computer
FCS	Flight Control System
GRA	Green Regional Aircraft
GUI	Graphical User Interface
ITD	Integrated Technology Demonstrator
JTI	Joint Technology Initiative
PBIT	Power-up Built In Test

1. Topic Description

CFP SHORT DESCRIPTION

The Green Regional Aircraft is a concept design intended to replace any non-electrically powered system to the maximum extent possible and focusing towards "oil-less power-by-wire aircraft" to reduce the impact of aviation on the environment.
In accordance with such a philosophy, it is required to study an Advanced Flight Control System architecture based on a redundant configuration with Electro-Mechanical Actuators to command the flight control surfaces of a Regional Transport Aircraft. Therefore it is important to take into account the possibility to employ an Electro-Mechanical Actuator and its associated digital Electronic Control Unit for a Primary Flight Control role in a future All Electric Aircraft into Green Regional Aircraft program.
For the above depicted scenario, the CfP main objectives are:

1. to design, develop and manufacture the EMA and its ECU, suitable for an FCS Primary actuation application
2. to design, develop and manufacture a Test Bench (suitable to integrate and test the EMA and ECU) with associated counter load and the inertial load simulation systems.
3. to perform a dedicated testing activity in order to verify and validate the EMA/ECU and Test Bench performance

After delivery, the EMA/ECU and Test Bench will be used for on **ground electrical test rig campaign on Copper Bird facility at Hispano-Suiza premises**, and also installed in a dedicated compartment area of an ATR72 aircraft for GRA AEA in-flight demonstration capability of integration with the

Electrical System
The Actuator will not be used to command any Aircraft surface for the purpose of this CfP; however a certain extent of design creteria and functions commonality with a full in-flight application will be considered in order to reduce the redesign activity of possible subsequent developments . The specifric environmental requirements are also according to this philosophy even though a limited exent of qualification is considered in order to reduce development efforts.

INTRODUCTION

The aim of this topic is to design, develop and manufacture

1. an EMA and its digital Electronic Control Unit (ECU), and
2. a Test Bench to integrate and test both the EMA and ECU.

For these reasons it is necessary to develop a Test Bench with counter-load and inertial loads simulation systems. Furhter details will be provided as an input by CfP topic manager at starting of the activity and during development phase.
The counter-load system will be used to simulate the aerodynamic loads opposing to the commands performed by the EMA. Moreover, the effect of the inertial loads insisting on the EMA will be simulated by means of a mass-balance system. Test Bench Command System (EMACS) shall generate the commands to the ECU control (e.g. position command) and record their performance (e.g., ram displacement, applied loads, currents, EMA motor temperature, etc.).
A drawing of the test environment including test bench, EMA and ECU is provided in fig. 1 for reference.
Based on a preliminary assessment it has been decided to study an actuation control system for the Rudder surface of the GRA

DETAILED DESCRIPTION

EMA/ECU DESIGN REQUIREMENTS

Equipment Architecture
The following requirements are meant to design the EMA and its associated ECU as much reliable as possible for a Rudder control surface actuation system.

- Linear type electro-mechanical actuator, Single electric motor architecture, controlled by means of a programmable digital Electronic Control Unit,
- EMA position dual sensor,
- Fail-Safe design, defined as a reversible-type actuator able to follow aerodynamic stream with pre-defined damping. An anti-jamming device must be included to prevent the actuator jamming in case of mechanical failure of the EMA.
- Two ECU communication channels for position command (ARINC-429 or RS-485 shall be considered as preferred serial interface; anyway the proposed serial interface will be discussed with the selected partner, and the design frozen at the PDR meeting). The ECU shall be powered at 28 V DC. The ECU shall have the capability to receive commands from the Test bench or from external Flight Control computers. Possible different type of communication standard could be evaluated during the development. A refresh rate for position command in the range of 100 Hz shall be considered.
- EMA no-load actuation rate shall be 140 ± 5 mm/sec.
- EMA stall load shall be within the range of 45.000 N and shall be sustained for 1 minute without damage.
- EMA shall be sized to react indefinitely a continuous load not less than 30.000 N.
- EMA shall be sized to provide a continuos mechanical power of 2,1 kW. Actuator rated speed with 30.000 N applied opposing load shall be 70 mm/sec as a minimum.
- EMA maximum break-out -backdrive force in fail safe condition shall not be higher than 1.000 N in

the overall temperature condition.

- EMA back-drive force shall increase with actuator speed in order to provide a damping function when the actuator is in fail-safe mode. Back-drive force at 140 mm/sec will be agreed with the selected partner during the development.
- EMA maximum output resolution required is 0,05 mm.
- EMA maximum allowed hysteresis is not greater than 0,1 mm.
- EMA accuracy shall not exceed 1% of actual commanded position, plus maximum 0,1 mm null bias.
- Position Frequency Response at ±1mm actuator displacement:

  phase lag: > -12 deg @ 1Hz, > -45 deg @ 5Hz

  gain > - 3dB @ 5Hz
- Stability Margin: gain margin 6 dB, phase margin 45 deg,
- The actuator static stiffness shall be higher than 60.000 N/mm.
- An internal Built In Test, comprising both a Power-up BIT and a Continuous BIT, shall be implemented within the ECU with self-monitoring capability. Further details will be agreed before and during the development activity with the selected partner.
- A programmable digital control loop shall be implemented within the ECU, by means of a suitable user interface. Together with the test bench, the selected partner shall deliver a test facility to allow the customer to update the Actuator Control Laws and modify monitor thresholds for experimental tests. Such modifications will be agreed with the selected partner. The position control laws shall run at minimum 200 Hz.
- The ECU shall allow an electronic rigging capability of the actuator stroke.
- A mathematical model, compatible with Matlab/Simulink™ and SABER™ tools, shall be delivered for numerical simulation purposes within GRA program including ECU digital control laws and physical EMA parameters

Internal stops

The EMA shall be equipped with mechanical stops to prevent exceeding the required total mechanical stroke, and it shall be designed to withstand without ruptures at least 50 bottoming with the inertia and bench stiffness connected. In no case the mechanical stops may cause the jamming of the actuator.
The EMA travel shall be limited electronically within the servo-loop control laws.

Electrical Connections

Electrical connectors and pin allocation will be agreed with the selected partner during the development phase, and configuration frozen at PDR meeting.

Mechanical Interface

The EMA shall be integrated on the dedicated test bench, and stimulated also by means of the test bench counter load systems.
The attachments shall be obtained by means of spherical bearings inside the eye-ends in order to allow the EMA to oscillate along its longitudinal axis.
Actuator design shall comply with the following requirements:

- Actuator working stroke = 150 mm
- Total (mechanical) actuator stroke = 160 mm

Rigging

Rigging procedure shall be defined according to the tolerances defined in the actuator unit drawings.

Mass

The total mass of the system composed by the EMA and the ECU, shall not exceed 15 kg.

Power Consumption

The maximum electrical power delivered to the EMA by the 270 VDC power supply shall be less than 2.8 kW. The actuator shall be capable to continuosly sustain such an electrical power without damage. ECU power consumption on 28 VDC shall be in the range of 100 W (this values will be further assessed with the selected partner during the development phase).

Reliability and safety

The EMA/ECU total MTBF shall be not less than 10.000 O.H. The EMA jamming probability shall be less than 10^{-6} per FH. The monitoring system shall be capable of detecting critical failures (the extent of the monitoring implementation will be agreed with the selected partner).

EMA Acceptance Test Procedure

The test bench shall have an option to implement an Acceptance Test of the EMA with the aim of verifying the EMA performance under both loaded and no-load conditions. The extent of the Acceptance Test Procedure will be agreed with the selected partner.

TEST BENCH DESIGN REQUIREMENTS

Test Bench Architecture

The following requirements are meant to design the Test Bench and its associated counter load and inertial load simulation systems as simple and reliable as possible to incorporate the EMA and its controlling ECU.

It is necessary to take into account that the entire test rig shall be installed also into the passenger compartment of a demonstrator aircraft for a flight testing activity and therefore the mass and the overall dimensions shall be minimized.

The test bench shall incorporate:

- A passive counter-load system (a spring device with selectable/variable stiffness could be a viable solution)
- A stiffness and inertial-loads simulation system. The simulated EMA lever arm shall be 130 mm, and the equivalent linear inertia shall be 1.750 Kg at mid stroke. The equivalent stiffness associated with the inertia shall be in the range of 30.000 N/mm. The test bench structural attachment stiffness shall be approximately 30.000 N/mm. An adjustable stiffness for the test bench attachment and the inertial load would be the preferable solution and will be discussed with the selected partner.
- A Test Bench Command System to generate and record the EMA commands and performance;
- Capability of failure injection (including the capability of testing the anti-jamming device).
- Capability to command the actuator with pre-defined waveforms: step input, linear slope with initial and final position and slope duration, sinusoidal with variable amplitude and frequency ranging from zero to 20 Hz.

Test bench interfaces and power requirements

The following power supplies will be provided to the test bench and EMA/ECU for ground and flight test:

On Copper Bird facility the following power supplies will be available to supply the test bench and the EMA/ECU:

For test bench power supply

- 230 VAC @ 50 Hz

For EMA motor power supply

- 270 VDC

For Electronic Control Unit power supply

- 28 VDC

Separate connectors shall be used for the different power supplies. The power connectors shall be of different type in order to prevent an operator power supply mis-connection.

For the test during the Flight Demo activities the following electrical power network will be provided by the Aircraft:

- a 115 VAC @ 338 to 493 Hz for test bench console,
- 28 VDC for Electronic Control Unit power supply,
- 270 VDC for EMA motor power supply.

Therefore the test bench and ECU shall have the capability to accept 230 VAC, 115 VAC, 28 VDC and 270 VDC via different connectors.

The test bench maximum power consumption including display and controls shall be lower than 1 kW. This value will be further assessed during the development phase. EMA power consumption provided via 270 VDC power is excluded from this computation.

Test bench recording capability

The test bench shall have the capability to record, store, plot and display the time-history of the main Actuator Physical parameters, e.g. actuator load, position, speed and currents, monitor failure flags indication at an adequate sample rate for real time and post run analysis. A detailed list of parameters will be agreed during the development phase

Electrical Connections

The Connectors and pin allocation will be agreed with the selected partner during the development phase.

Mechanical Interface

The test bench shall accommodate the EMA and its ECU so, the test bench design and associated counter-load system shall comply with the EMA design and requirements.

Mass

The maximum mass, including the simulation load system, shall be less than 250 kg.

Bench Size and Restraint Requirements

Considering the need to install the bench on the demonstrator aircraft, the size of the bench shall allow the loading of the bench through the ATR cargo door (cargo door dimensions: 1200mm width; 1650mm high) without any interference with door contours. If cargo handling system (e.g use of ball mat to rotate and translate the bench inside the cabin) will not be installed the bench needs to be composed by multiple parts, where each one shall not exceed the weight of 40 kg to allow the operator transportation.
In this case, the bench shall be designed to be easily assembled and disassembled in order to satisfy the above requirements.
At the moment of the issue of present CfP the presence of the cargo-handling system is still in evaluation.

The design of bench attachment to the floor seat tracks shall comply to the CS 25.561 requirements.

EMA and ECU Qualification Activities

Fatigue/Endurance

The endurance test program shall be based on full loads, full stroke cycles as well as low loads, short stroke cycles under different operating conditions performed at usual lab ambient temperature.

The following table provides the test cycles program corresponding to 25.000 flying hours

Section	f [Hz]	Number of cycles per 25.000 FH	Amplitude displacement around actuator mid-stroke position [mm]			Actuator load amplitude [N]		Superimposed cycle		
			from	to	to	from	to	f [Hz]	Amplitude [mm]	Load variat. [N]
A.	0.25	10	+75	0	-75	+30.000	-30.000	1	±3	±500
B.	0.25	$2*10^3$	+50	0	-50	+25.000	-25.000	1	±3	±500
C.	0.25	$3*10^6$	+75	0	-75	+10.000	-10.000	1	±3	±500
D.	0.5	$3*10^6$	+25	0	-25	+10.000	-10.000	1	±3	±500
E.	-	$6*10^6$	-	-	-	-	-	1	±3	±500
F.	-	$7.5*10^4$	+75	0	-75	-	-	-	-	-

A scatter factor of 2 – applied to the cycles specified into the table above – is required for Endurance testing, 4 for Fatigue testing. A useful life of 1.500 operating hours shall be demonstrated by test.

ENVIRONMENTAL CONDITIONS

The design goal for an airworthy Rudder control system is to achieve a full environmental qualification evidence in accordance with the applicable requirements of the DO-160F documents. Nevertheless, considering that the experimental activity concerning the EMA, the ECU, and the Test Bench would be performed both in a lab environment (i.e., at the selected partner's premises and at Copper Bird facility) and on a flying demonstrator (installing the Test Bench, the EMA and the ECU into a dedicated test area in the passenger compartment of the airplane), a limited qualification activity would be required to be performed by the selected partner.
The Components shall meet the requirements and shall provide performance taking as reference the DO-160F.
The EMA and its ECU shall be subjected to the following test in accordance with the DO-160F to show compliance to the specified requirements:

- Temperature / Altitude,
- Vibration
- EMC / EMI
- Magnetic effect

The detailed qualification tests procedures will be agreed with the selected partner.
The selected partner shall take into account the following environmental requirements for the design of the EMA/ECU and Test Bench.

Temperature:

For the EMA,, DO-160F, section 4, table 4.1, Category C2 equipment temperature conditions (-55°C to +70°C) are applicable for continuous and short time operations. The equipment shall be capable to satisfy operations following prolonged exposure (non operating) to a -55 °C to + 85°C environment.
Due to commercial electronic constrains, a lower limit of -40°C (operating) is considered for the ECU design.

Vibration

The EMA/ECU shall operate satisfactorily when subjected to continuous vibration over the frequency

range of 5 to 500 cycles per second having an amplitude envelope as shown in curve T of Fig. 8-3 of DO-160F. The equipment shall be capable of meeting the above specified vibration requirements when tested in any possible attitude, and when subjected to the condition described in the test procedure in compliance with paragraph 8.5.1 of DO-160F. During the preliminary resonance search test, as the sinusoidal sweep rate must not exceed 1 octave/minute, according to the terms of sub-paragraph 8.3c of DO-160F, this rate must be limited to 0.5 octave/minute whenever possible. Three axis recordings must be made for all resonance search test carried out in compliance of DO-160F.
Vibration tests according to the above requirements shall be foreseen by the selected partner activity

The following tests are intended for both EMA/ECU and Test Bench:

Power Input Quality

The equipment shall satisfy the requirements of MIL-HDBK-704.

EMC/EMI

Emission of Radio Frequency energy

The electromagnetic effects of the EMA/ECU and test bench shall be demonstrated by test in accordance with the test requirements as per section 21, category M of DO-160F
The following DO-160F sections are to be taken as reference only for ECU/EMA design criteria even though no test is required:

Audio Frequency Conducted Susceptibility

RTCA/DO-160F, Section 18 - Category R(WF) for AC equipment and R for DC equipment

Induced Signal Susceptibility

RTCA/DO-160F, Section 19 - Category ZW for AC equipment and ZC for DC equipment

Radio Frequency Susceptibility (Radiated and Conducted),

RTCA/DO-160F, Section 20 - Category WW

Magnetic Effect

The magnetic effect of the complete equipment, classified in Category A, shall be demonstrated in accordance with the test requirements per section 15 of DO-160F.

Bonding

The construction of the components shall be such that metallic parts not associated with the electrical functioning of the unit, will be electrically bonded together with a maximum resistance between any two parts of 25 milliohms throughout the life of the equipment. It is allowed a derogation for movable part.

Specific tooling, consummable and wearing parts

All the special tools needed to perform daily maintenance, assembly/disassembly handling, extracting, fitting in parts shall be provided. However the need for special tooling shall be minimized as possible.
Component batch shall provide wearing parts (such as filters, gaskets, etc.) in the appropriate quantities to satisfy the test campaign constraints and schedule.

Delivery

Delivery of EMA/ECU and the Test Bench. Test Bench and relevant documents package on the Copper Bird electrical test rig, at Hispano-Suiza premises (Paris area, France) and then at ATR Flight Test site (Toulouse, France).

Others (review meetings)

A Preliminary Design Review meeting will be held at M4 to freeze the interfaces and the performance of the system and of the related test bench. It will be followed at M8 by a Critical Design Review meeting in order to freeze the detailed design of all the components with the agreement of the Topic Manager.

Customer Support:

The selected partner shall provide customer support for a period from the date when the equipment is delivered in its final form until completion of ground and flight tests (scheduled completion of the research project: end of December 2015). Customer support activities to be performed by the applicant shall include user familiarization with the system, resolution of possible problems, minor changes to improve GUI or functionality.
Moreover, the supplier shall guarantee and repair the delivered items in case of items defects or damages.

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

The Candidate organization shall have:

>a well recognized background on electrical actuation and power electronics
>expertise in aviation electromechanical systems

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	EMA/ECU Technical Description	EMA Technical Description shall include detailed architectural description, performance evaluation and reliability figures.	M4
D2	Test Bench Technical Description	Test Bench Technical Description shall include detailed architectural description and performance evaluation.	M4
D3	EMA/ECU Interface Control Document (Preliminary)	Mechanical and electrical EMA interfaces, detailing also the EMA control laws and monitoring SW description and parameters list.	M4
D4	Test Bench Interface Control Document (Preliminary)	Mechanical and electrical interfaces,	M4
D5	EMA/ECU Outline Drawings and Part List (Preliminary)	Overall dimension drawings and Part List.	M4
D6	Test Bench Outline Drawings and Part List (Preliminary)	Overall dimension drawings and Part List.	M4
D7	PDR report	PDR meeting Note	M4
D8	EMA/ECU Interface Control Document	Mechanical and electrical EMA interfaces detailing also the EMA control laws and monitoring SW description and parameters list	M8
D9	Test Bench Interface Control Document	Mechanical and electrical interfaces,	M8
D10	Stability and Controls	EMA Control laws design criteria and stability analysis	M8
D11	EMA/ECU Outline Drawings and Part List	Overall dimension drawings and Part List.	M8
D12	Test Bench Outline Drawings and Part List	Overall dimension drawings and Part List.	M8
D13	CDR report	CDR meeting Note	M8
D14	Mathematical model for EMA and ECU	A mathematical model, compatible with Matlab/Simulink™ and SABER™ tools, to adequately simulate the response of the EMA.	M9
D15	Components 3D mock-Up	3D digital mock-up of the components in CAD model or CATIA V5 **R19.**	M9
D16	Qualification Test Plan	Schedule, location, and type of qualification tests description	M10
D17	Test bench Acceptance test	Test bench and EMA acceptance test procedure	M13
D18	Qualification Test Procedure	Detailed qualification test procedure including test description, facilities description and characteristics, procedure and pass fail criteria	M13
D19	Operating instruction manuals	The assembly, disassembly, maintenance and functional components manual and sensors calibration data and description sheet.	M16
D20	Components Final Test Report, ATR and DDP.	Final summary report, Acceptance Test Report and Declaration of Design and Performance.	M16
D21	EMA and Test Bench delivery	Delivery at Copper Bird electrical test Rig (Hispano-Suiza premises, Paris area, Francia)	M16

Note: Some documents could be merged into a single document for supplier convenience, provided that the content of the single documents are maintained. Document splitting shall be agreed with the purchaser.

4. Topic value (€)

Budget: The total value of the proposed package shall not exceed **€ 1.100.000** for EMA (including ECU) and for Test Rig. (one million one hundred thousand Euro) including all cost categories (personnel, computing, travels, etc.). **Funding**: ranging from 50% to 75% of the budget

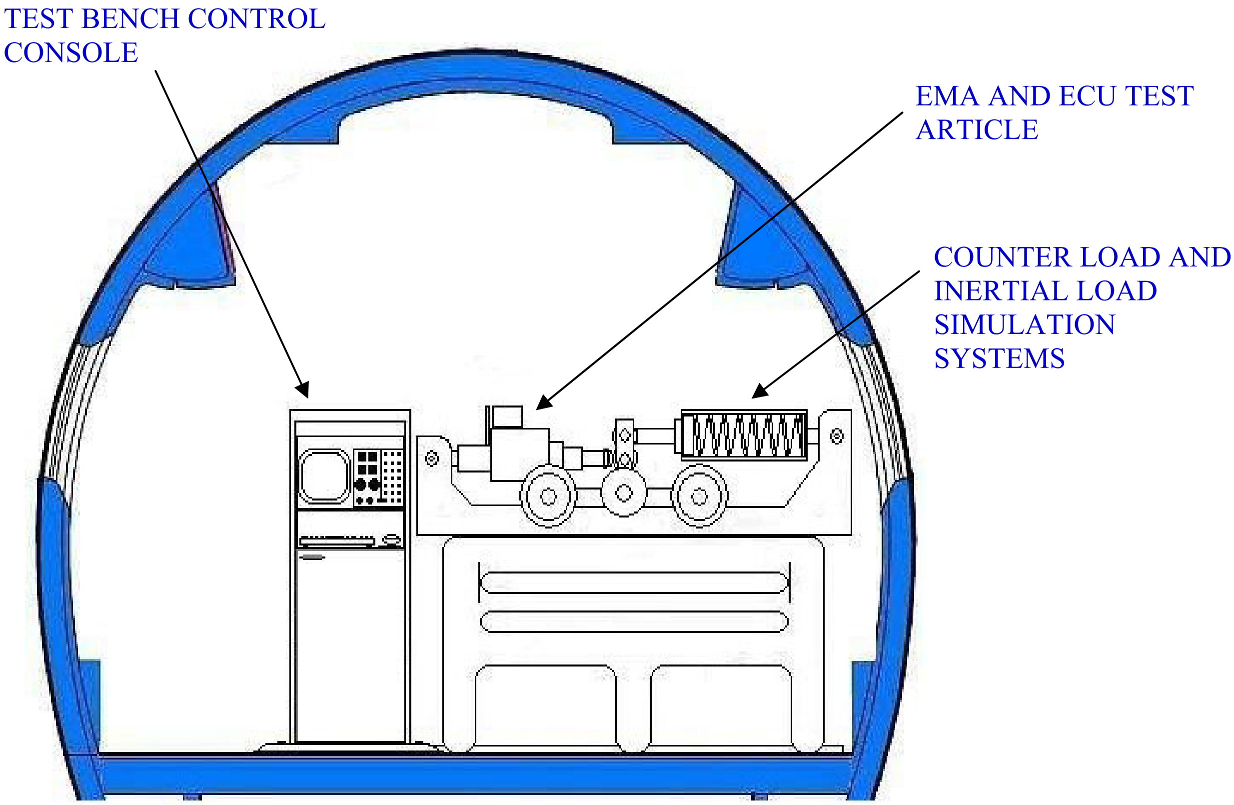


Fig. 1 – Installation concept drawing of EMA, ECU and their Test Bench on the demonstrator airplane.

Topic description

CfP topic number	Title		
JTI-CS-2012-01-GRA-03-010	**Electrical Power Centre with Control Console for In-Flight Demo**	**End date** **Start date**	*T0 + 18 Months* *T0*
Design, development, manufacturing, testing and delivery of an electrical power distribution box with integrated command console for the control of some innovative electrical power consumers within the in-flight demonstration activities of the All-Electric Aircraft domain of GRA ITD			

List of Acronyms

AC: Alternating Current
AEA All-Electric Aircraft
A/C: Aircraft
CC: Control Console
CfP: Call for Proposal
DC: Direct Current
E-ECS: Electrical Environmental Control System
E-EM Electrical Energy Management
EMA: Electro-Mechanical Actuator
EPC: Electrical Power Center
EPDS: Electrical Power Distribution System
EPGDS: Electrical Power Generation and Distribution System
GCU: Generator Control Unit
HVDC: High Voltage Direct Current
H-WIPS: Hybrid Wing Ice Protection System
ICD: Interface Control Document
ITD: Integrated Technology Demonstrator
JTI: Joint Technology Initiative
SSPC: Solid State Power Controller
TBD: To Be Defined
TM: Topic Manager

1. Topic Description

CFP SHORT DESCRIPTION

The aim of this topic is to design, develop, manufacture, test and deliver an Electrical Power Center (EPC) and its dedicated Control Console (CC) for the in-flight demo activities of AEA domain of the Clean Sky GRA ITD. For this purpose, the EPC and the CC will be installed in an ATR-72 (GRA selected flying demonstrator) passengers cabin, being able to interface with the aircraft overall Electrical Power Generation System (EPGS).

The overall equipment (EPC+CC) shall also allow the verification of the innovative Electrical Energy Management (E-EM) concept and control logics. As a matter of fact, due to the ever growing number and power of on-board electromechanical actuators and overall electrical loads, efficacious supervision and management control strategies are necessary in order to reduce the energy consumption so as to optimize the overall weights and volumes of on-board Electric Power Generation and Distribution System (EPGDS).

The E-EM function (operated by the EPC and controlled by the CC) to be tested will consist in applying the control logics to some selected power consumers trying to keep the overall electrical loads within the nominal rate of the generator (40 kVA maximum) dedicated to the demo channel, for each combination of loads in steady or temporary state.

The control logics to be implemented in the EPC in dedicated electronic boards will be provided by the Topic Manager at the early stage of the Project in the form of logical equations and they will constitute one of the main inputs necessary to start the CfP activities.

Within the above depicted scenario, the CfP main objectives are:

- designing and manufacturing of an EPC and its dedicated CC for the GRA AEA in-flight testing activities;
- providing outline mechanical drawings and defining electrical interfaces;
- testing the EPC and CC in order to verify main characteristics and performance;
- delivering on site and commissioning of the complete equipment.

The following additional objectives will constitute a preference in the proposal evaluation process:

- providing a software package able to pre-test all the EPC configurations by software before testing in real on the hardware and having the possibility to compare the simulation results and the measurements performed during the real test on hardware. This tool shall also be able to simulate and programme the control logics and Electrical Energy Management algorithms so as to automate the EPC;
- providing a mathematical model (SABER behavioral) of the EPC for virtual testing in an global simulation environment;
- supporting directly (eventually on site) the in-flight test campaign assuring EPC and CC maintenance and eventually repair.

INTRODUCTION

The trend that GRA ITD “All-Electric” Aircraft domain is currently investigating will probably make electrical generators rated size higher and higher. This implies that no overload capacity can be taken into account in the design, as long as weights and volumes are desired to stay within objective figures for aeronautical application. Moreover, most essential loads are changing into electrical power consumers (electrical flight controls, brakes, ice protections, environmental control system, etc.), therefore they can’t be easily shed. The way proposed to face these key steps towards a new concept electrical network is an innovative *Electrical Energy Management* (E-EM) distribution policy.

Currently, any abnormal electrical condition (e.g., one generator missed, equipment power-up phase), that results into an extra demand of electrical power, is addressed to the overload capacity of generators. Besides, shouldn’t this features be enough to manage the peak power request, several loads may be totally shed as they are not flight or safe-landing essential. This conventional policy is the so called “load management”.

By definition, E-EM is an *advanced smart control* of aircraft electrical loads *optimizing weight, volume and consumption*, being able to *“smooth” extra power demands* due to power transients and/or to electrical failures (normally addressed to the generator overload capacity) by compensating them with a proper reduction of the power demand from those loads which are “non critical” for that specific flight phase or operating condition.

The E-EM basic principle is to force global electrical power demand to decrease, even during an extra demand condition. But, unlike the conventional load management, the selected consumer, suffering the power decrease, is far from being shed. However, the shedding of loads (a peculiarity of conventional load management) still continues to be applied, and it may be regarded as a boundary condition of E-EM.

The management of overload capacity is then accomplished *at a distribution level* while the generators are going to be sized for the heaviest power demand which, thanks to the E-EM policy, corresponds to the nominal one.

As future generators will be sized for nominal power only, without any overload capability, *should an extra power demand occur, it will be addressed to selected “power sink” loads*, without any modification to the critical loads power provision (EMAs and hybrid WIPS), but also without impairing the power sink load itself.

It has to be noted that the 40 kVA generator intended to be used on the GRA flying demonstrator is a conventional machine and therefore it does have the capability to be overloaded up to 45 kVA for 5 minutes and 60 kVA for 5 seconds.

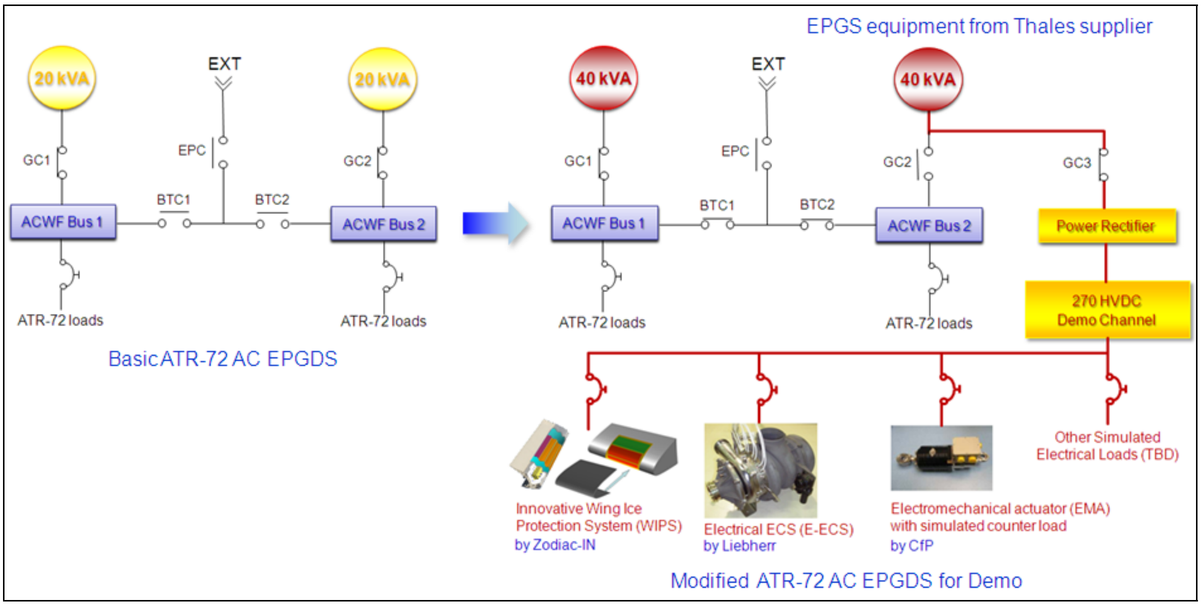
The EPC controller (implementing the control logics) allocates for the selected loads a power reduction request that is function of several parameters, such as:

– Load-peculiar parameters, function of the specific flight phase or operative mode (priority, critical state);

– Network parameters, as trend towards saturation of generators nominal capacity (di/dt).

DETAILED DESCRIPTION

The GRA AEA in-flight demonstration will be organized around the EPC (actuated by its dedicated CC) which shall distribute the electrical power from the 270 HVDC dedicated demonstration channel to the demo electrical power consumers (i.e., E-ECS, H-WIPS, EMAs, simulated loads) and it shall also implement the control logics of the innovative E-EM concept, managing power allocation between different kinds of real and simulated loads.



ATR-72 EPGS modification with demo loads for in-flight testing objectives

270 HVDC Demo Channel Network

The increased amount of electrical power demand for the future all-electric regional aircraft would dramatically affect either the size and weight of cables and bundles, or the power losses throughout the network, should the voltage stay at low level. Therefore, the choice of rising the voltage is compulsory to a good design.

In this framework, the selected 270 DC high voltage level is tailor-made on small all-electric a/c needs, being already an aeronautical standard (ref. MIL-STD-704F). As a consequence, all the electrical demo power loads will comply at the input stages with the limits identified in the above standard.

The EPC shall take 270 HVDC power supply from modified aircraft EPGS and it shall distribute the power to the demo actual and simulated load consumers (i.e., *E-ECS*, *H-WIPS*, *EMAs* and *Programmable Resistive Electrical Loads*).

Note: Alternative voltage levels (28 VDC, 115 VAC) will be also available on aircraft for EPC and CC auxiliary power.

Although the limited size of ATR demonstrator Electrical Power Generation System (no more than 40 kVA will be available for demo), the in-flight test activities shall allow the verification of E-EM concept. As a consequence, the in-flight demonstration shall be limited to the following configuration that is compatible with the electrical power available:

– *E-ECS* (Electrical Environmental Control System): ≤ 35 kW;

– *FCS EMA* (Flight Control System Electro-Mechanical Actuator): ≤ 3 kW (*);

– *MLG EMA* (Main Landing Gear Electro-Mechanical Actuator): ≤ 7 kW (*);

– *Hybrid WIPS* (Wing Ice Protection System): ≤ 3 kW (*);

– *Programmable Resistive Electrical Loads* (non-essential loads): ≤ 20 KW

(* = critical load, power provision non modified by E-EM)

Each demo load can have one or more power supply inputs from the 270 HVDC bus bar inside the EPC.

Each power supply input shall be provided through a power switching device (e.g., contactor or relay) included into the EPC, driven by the CC.

All the necessary technical characteristics of the demo loads (actual and simulated ones) will be provided to the CfP applicant at the early stage of the project.

Electrical Energy Management Function

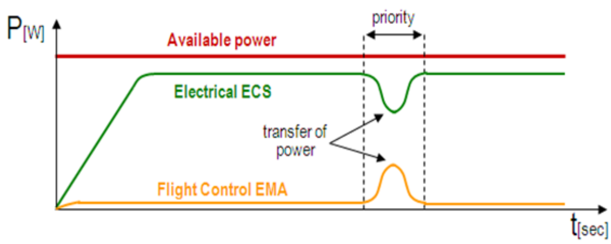
As an objective, the E-EM concept verification tests on the GRA in-flight demo shall consist in applying the E-EM control logics to the demo power consumers trying to keep the overall electrical loads within the nominal rate of the AC generator, for each combination of loads in steady or temporary state. That mainly by:

– enforcement of priorities between power consumers;
– controlled transfer of power without relying on generator overload capability;
– cooperation with network active stabilization function.

The possibility of monitoring the generator total current and its derivative (providing a status on how it is nearing generator capacity saturation) shall give the opportunity to verify the E-EM concept and control logics.

The EPC shall operate in order to react to current requests near to generation saturation treshold, therefore avoiding overload; in this case, the EPC shall send logical signals to the *E-ECS* and to the *Programmable Resistive Electrical Loads* to request the appropriate power degradation.

As part of the Electrical Energy Management experimentation, the *E-ECS* and the *Programmable Resistive Electrical Loads* will be the “fly-wheel” (i.e., the “power-sink”) from which the necessary power to support the transient electrical conditions shall be taken (without modifying the power provision of critical loads).



E-EM concept

The *E-ECS* will be the only load suitably selectable as power sink on the GRA in-flight demonstrator (as the power modulation does not affect its well functioning unless its average value overcomes a predefined extent). The E-ECS power modulation shall be completely addressed to the load itself which shall receive from the EPC a command signal only:

$$P_{ECS}^{min} \leq P_{ECS} \leq P_{ECS}^{nom}$$

The delta power $P_{ECS}{}^{nom}$-P_{ECS}, that can be tuned on network instantaneous needs, shall stand for the conventional *5 minutes* overload capability of generators, now addressed at distribution level.

The *Programmable Resistive Electrical Loads* shall be powered through an *Advanced Power Supply Module* (not object of this CfP) which shall receive from the EPC the driving signal to reduce power absorption of *Programmable Resistive Electrical Loads*: the network voltage applied to the loads shall be chopped by the *Advanced Power Module* and it shall result in power modulation. But, unlike conventional load management, this non-essential loads, suffering the power decrease, shall be not shed, as the chopping shall be pushed just to a predefined extent. Note that the total shedding shall still continue to be applied and it shall be regarded as a boundary condition of the E-EM.

Modulated power addressed to the *Programmable Resistive Electrical Loads*, that shall compensate the short electrical power transients that the inertia of E-ECS power modulation is not able to compensate, shall stand for the conventional *5 seconds* overload capability.

The EPC shall continuously monitor the total 270 HVDC current and its derivative versus time (monitoring shall be done inside the EPC); when overload conditions are foreseen, the following actions shall be performed by the EPC:

1. send a logic signal to the E-ECS motor driver to request the power degradation;
2. send driving signals to the *Advanced Power Supply Module* that will quickly reduce power absorbption of *Programmable Resistive Electrical Loads,* according to different priority levels of loads (function of the phase of flight).

Control Console

The CC shall enable the cabin operator to energize the in-flight demo and to monitor the overall E-EM concept verification.

The CC shall include a panel containing the following control devices:

- Master switch with power status indication to enable Demonstration Channel energization, interfaced with the aircraft EPGS;
- Manual switches with power status indication, to enable demo consumers 270 VDC energization through the power switching devices (e.g., contactors or relays) included into the EPC; for each switching device, when actuated, a 28 VDC signal shall be made available at the dedicated electrical interface, to drive aircraft switching devices actuating alternative power levels (28 VDC and 115 VAC) available for demo consumers auxiliary devices (electronic cards, cooling fans, etc.);
- Control keys (i.e. potentiometers) to allow *Programmable Resistive Electrical Loads* setting (from zero to full-range) by an analogic voltage signal.

The CC shall include one or more displays indicating:

- Total EPC input power;
- 270 VDC bus bar voltage;
- Status of the E-EM signals to E-ECS and to Simulated Resistive Loads;
- Specific loads current/power.

<u>DESIGN REQUIREMENTS</u>

In general, Civil Certification requirements (CS 25) shall be used as reference when and if applicable.

CfP applicant is requested to put particular attention to EPC weight and volume with respect to the state-of-the-art technology. Therefore, any technological improvement aimed to weight and volume savings shall be taken into account.

The proposal of a Health Monitoring system for failure detection, preferably integrated with the E-EM function, will constitute a preference in the proposal evaluation process.

Interface Requirements

Detailed mechanical installation, electrical and cooling interfaces requirements will be provided as an input in the early stage of the Project.

A dedicated procedure and any necessary special tools shall be provided by CfP applicant in order to allow assembly on the aircraft.

Parameters to monitor

The following parameters shall be monitored as a minimum and made available at the dedicated electrical interface:

- Total EPC input current;
- 270 VDC bus bar voltage;
- Status of the E-EM signals exchanged with E-ECS and Simulated Resistive Loads;
- Specific loads currents.

Weight

Estimation of the EPC and CC weight rough figures shall be provided by the CfP applicant at the early stage of the Project.

Support

The applicant shall provide customer support for a period from the date when the equipment (EPC+CC) is delivered in its final form until completion of flight tests (which are scheduled until the end of 2015). Customer support activities shall include user familiarization with the equipment, resolution of possible problems, minor changes to improve functionality. Moreover, the CfP applicant shall guarantee and repair the delivered items in case of defects or damages.

Software for Simulation Activities

The EPC shall be equipped with a software package able to pre-test all the EPC configurations by software before testing in real on the hardware and having the possibility to compare the simulation results and the measurements performed during the real test on hardware. This tool shall also be able to simulate and programme the control logics and E-EM algorithms so as to automate the EPC.

The possibility of an automatic or semi-automatic translation of the E-EM strategy from the simulation environment to the electronic boards programming language will be particularly valuable for CfP evaluation.

Model for Simulation Activities

The overall equipment (EPC+CC) model shall be provided for simulation activities in a global simulation environment at behavioral level. It shall reflect the actual equipment behaviour in term of static and dynamic main features in order to perform both steady state and transient time domain analysis. The model shall be preferably released in SABER simulation code. In order to verify the control logics , it should be possible to adopt a software package different from the modeling tool, appropriately interfaced, for coping with the control logic complexity.

QUALIFICATION TESTS

The following qualification testing activity shall be conducted, as a minimum, in order to demostrate compliance with equipment performance and functionality and assure a sufficient safety of flight level, necessary to allow in-flight test demo application.

Qualification Testing

1. Functional test;
2. Power Input test;
3. Insulation resistance test;
4. Dielectric strenght test.

Safety of flight for in-flight test demo

1. Shock test (crash safety test);
2. Mechanical vibration test;
3. Emission of radio frequency energy test;
6. Bonding /earthing test;
7. Fire (justification).

Standards to be used as main references for these tests are: DO-160F, ISO 2678, MIL-STD-704F, MIL-STD-464.

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

The Candidate organization shall have:
f. expertise in electrical system design (power generation, power conversion, power network, power consumer),
g. knowledge of Industrial/Aeronautical field constraints and procedures,
h. experience in system simulation methods and modelling, preferably in SABER environment,
i. good practice in English language.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
I1	Design Requirements and Data	Input document from CfP manager containing detailed requirements and data (e.g., control logics in the form of logical equations) necessary for CfP activities starting	T0 + 1 month
D1	Equipment Outline Drawings	Technical document containing overall equipment (EPC+CC) dimension drawings and rough weight estimation	T0 + 3 months
D2	Equipment Technical Description	Technical document including detailed equipment (EPC+CC) description and performance evaluation	T0 + 5 months
M1	PDR	Preliminary Design Review meeting and associated supporting documentation	T0 + 6 months
D3	Equipment Interface Control Document	Technical document including mechanical, electrical and cooling interfaces	T0 + 8 months
D4	Qualification Test Plan	Test Plan document including as a minimum the following information: • list and description of test facilities, • test equipment list, • specific environmental conditions, • tests description.	T0 + 10 months
D5	Qualification Test Procedure	Technical document including detailed procedures for qualification tests.	T0 + 11 months
M2	CDR	Critical Design Review meeting and associated supporting documentation.	T0 + 12 months
D6	Delivery and commissioning	Delivery of the complete equipment (EPC+CC) with associated documentation (assembly, disassembly, maintenance and functional components manual), installation and commissioning on site.	T0 + 16 months
D7	Qualification Test Report	Technical document including results of qualification tests.	T0 + 17 months
D8	Declaration of Design and Performance		T0 + 18 months
M3	Support	Support during assembly and test activities (whenever required) until completion of testing activities.	

4. Topic value (€)

Budget: the total value of this work package shall not exceed:

300000,00€

[three hundred thousand Euro]

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

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

Clean Sky – Green Rotorcraft

Identification	ITD - AREA - TOPIC	topics	VALUE	MAX FUND
JTI-CS-GRC	**Clean Sky - Green Rotorcraft**	**4**	**1.450.000**	**1.087.500**
JTI-CS-GRC-01	*Area-01 - Innovative Rotor Blades*		**400.000**	
JTI-CS-2012-1-GRC-01-008	Mould design and manufacture for the production of a very high tolerance model helicopter blade		400.000	
JTI-CS-GRC-02	*Area-02 - Reduced Drag of rotorcraft*			
JTI-CS-GRC-03	*Area-03 - Integration of innovative electrical systems*		**650.000**	
JTI-CS-2012-1-GRC-03-012	Development and delivery of EMA for a light helicopter		650.000	
JTI-CS-GRC-04	*Area-04 - Installation of diesel engines on light helicopters*			
JTI-CS-GRC-05	*Area-05 - Environmentally friendly flight paths*			
JTI-CS-GRC-06	*Area-06 - Eco Design for Rotorcraft*		**400.000**	
JTI-CS-2012-1-GRC-06-005	Recycling of Metallic Materials from Rotorcraft Transmissions		200.000	
JTI-CS-2012-1-GRC-06-006	Disassembly of eco-designed helicopter demonstrators		200.000	

Clean Sky Joint Undertaking
JTI-CS-2012-01-GRC-01-008

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-GRC-01-008	**Mould design and manufacture for the production of a very high tolerance model helicopter blade**	**End date**	T0+18M
		Start date	T0

1. Topic Description

1. 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 a reduced tip speed of its main rotor whilst preserving current flight performance capabilities. Lower main rotor speed alone will significantly reduce rotor noise and fuel consumption, but without ART would otherwise severely compromise flight speed and payload.

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 , 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 as the rotor blade rotates around the helicopter.

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 (ie progressively extended/retracted) as the blade rotates around the helicopter.

In order to assess the capabilities of an AGF configuration it is intended that system demonstrators be manufactured, trialled and evaluated. Some of these will operate within full scale rotor blade sections, however before ultimately committing to longer term flight trials, much valuable work can, and has to be done at a model rotor level. The GRC-1 consortium therefore intends to design, develop and test a model helicopter rotor system that will incorporate a scaled active Gurney flap mechanism.

Note; the reference here to a model scaled rotor system refers to using a ground (fixed) experimental rotor rig system operated within a wind tunnel, not a radio controlled small scale helicopter.

A description of the typical upper limits of size that would be expected for such a model rotor system follows:

number of blades	4
blade radius	1.1 m
blade chord	90 mm
blade twist (centre line to tip)	8°
1st aerofoil section radius	0.231 m
aerofoil profile – full span	NACA0012
tip planform	Rectangular
direction of rotation	CCW top view

Table 1. Model rotor configuration

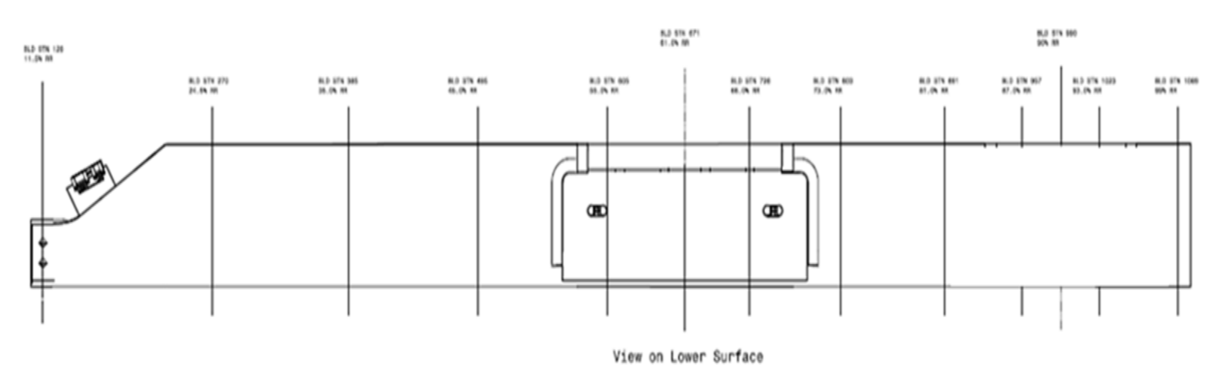


Figure 4 Blade section showing the AGF element area as currently anticipated

To achieve these aims the Green Rotorcraft Consortium, with lead guidance provided by The Topic Manager, request bids from companies or consortiums to design, develop and provide a tooling system, which will be used to manufacture the wind tunnel model rotor blades. The blades will be made from Aerospace standard composite materials via differing manufacturing methods.

Existing Green Rotorcraft Consortium to supply/control :

Design description of the blade and the parts that make up the blade. Typical expectations are that the spar will be a fabricated solid moulding, probably of carbon fibre. The trailing edge skins will be of thin composite material construction (again probably carbon fibre) and the trailing edge of lightweight foam such as Rohacel. The AGF mechanism, manufactured in advance, will be fitted into a pocket removed from the skinned blade, over which a closing panel will be fitted. The exact definition of the blade is however the subject of soon to be started design activity hence is not yet fully defined. Note: It is currently *not*e expected that the blade will be made as a one shot moulding due to the complexity of electrical connections required to provide power to actuators in the AGF region as well as the provision of data sensor output (strain gauges, position sensors etc).

The design definition of the blade will be supplied as a computer generated model. Catia V4 and V5 are standard; however it may be possible to transfer such models into other formats.

Successful Bidding Organisation to supply:

- A suite of tools suitable for the moulding of the above blade from composite materials by processes conversant with producing components with the following typical properties: the fibre volume fraction required is typically 57% and voiding has to be less than 1 percent. Composite ply position stop offs (spanwise and chordwise) are controlled to 0.25mm accuracy. The tooling and curing process must be designed so as to minimise any deformation of the manufactured items on release from the tool, since very tight geometric tolerances are required.
- Areal composite ply weight is very carefully controlled to typically +/- 3 % about nominal.

2. Scope of work:

The AGF will be incorporated into model helicopter rotor blades manufactured from composite materials, having an approximate 90mm chord (aerofoil section)and approximately 1100 mm total span. The AGF region would have a span of approximately 100mm and be centred at about 65% of the rotor radius. The blade section will be of NACA0012 profile potentially with an enlarged thickness trailing edge tab profile in the AGF region as detailed in Figure 4.

The successful bidder will design and manufacture mould and tooling sets for two different manufacturing processes that will enable the desired properties of the blade and comparisons to be made between the methods. The two manufacturing processes are:

- Pre-pregging
- Resin transfer moulding (RTM)

The successful bidder(s) would be expected to:

a) Design tooling sets for prepregging and RTM concepts capable of producing the scaled rotor blades using aerospace qualified composite materials. The following is considered part of the tooling design:

- *Design of moulds capable of meeting the strict dimensional requirements of the rotor blade*
- *Method for opening and closing the moulds. Either by means of a press or a self-contained system (tbd)*
- *Methods for heating and cooling the mould - Design of removable cores; reusable cores or lost cores (tbd)*
- *Design of preform tooling, including a mould for a solid fibre D-spar*

b) Manufacturing of the mould sets, including all subcomponents and preform tooling as well as tooling required to produced finished blade test pieces for evaluative testing. The expectations are that the following tools will be required as a probable minimum set although this will be subject to consideration/change as the design of the blade progresses and/or the manufacturing process evolves;

- *Spar tool*
- *Skinning tool (master blade profile)*
- *Profile forming tool for composite material packs required for the manufacture of substantiation test specimens*
- *Tool for AGF region cover patch*
- *Other - to be defined.*

c) Process testing/shape monitoring in order to validate the functionality of the mould and demonstrate that the parts will meet all requirements

d) Integration of temperature sensors to monitor the curing process.

<u>Testing prior to acceptance</u>

The tooling will have to undergo the following <u>and other</u> tests in advance of their being considered for the production of the wind tunnel rotor blades:

a) Geometrical measurements to validate the form and dimensions of the tooling.

b) Heat survey to validate thermal behaviour of the mould, including heat-up rates and temperature uniformity of the mould.

c) Manufacture of one validation article per manufacturing process to demonstrate the functionality of the mould, including dimensional measurements of the moulded part and non destructive testing and destructive testing of the moulded part.

The costs of the above tests will be covered by the successful bidder

Further additional tests will be carried out by the existing CleanSky consortium to ensure that the whole blade tooling is functionally fit and safe for purpose.

e) A report detailing possible routes for the industrialisation and manufacturing of the full-scale rotor blades.

Expectation of the bidder

The bidder, amongst other things, will be required to:

- Provide a detailed *Specification* for the tooling suite in response to the Topic Manager's *Requirements Specification* provided at the start of the tasking.
- Assist the consortium member in the detailed design of the part in order to improve the manufacturability of the rotor blades.
- Design critical elements of the tooling (defined in the scope of work above) in collaboration with GRC1 members.
- Demonstrate the functionality of the tools by means of validation articles.
- Deliver complete sets of tooling and equipment, including any cores, necessary for the manufacturing of the model rotor blades.
- Assist in the technology transfer in order for the consortium member to be able to manufacture the rotor blades themselves.

Note: The GRC1 Topic Manager will provide the preliminary rotor blade design details at the start of the programme as far as they are understood at that point in time.

Leading Particulars:

1. The wind tunnel rotor blades will be manufactured using prepreg and RTM technologies, using aerospace certified materials. The exact reinforcement materials are still to be determined.
2. The prepregmoulds, including product, should be capable of reaching and holding a temperature of 120°C, with a deviation of less than ±3°C over the product area. The filled mould heat-up and cool down rate shall be controllable.
3. The RTM mould, including product, should be capable of reaching and holding a temperature of 180°C, with a deviation of less than ±3°C over the product area. The filled mould heat-up and cool down rate shall be controllable and capable of at least 3°C/min.
4. The rotor blades will be fitted with an Active Gurney Flap (AGF) mechanism, which will require a (partially) hollow structure and the ability to access this internal space after the mould process. As the AGF has not yet been designed, the particular details will be provided at the start of the programme.
5. The rotor blades are subjected to very high rotational forces, up to 3000G on the blade tip, which results in very strict requirements on identical mass distribution between each of the four rotor operating blades that will be produced. The target is better than ±3% variation in mass distribution, both locally and globally, between each blade.
6. The dimensional tolerances are yet to be determined but are expected to be very high: <±0.1mm on the aerodynamic profile.

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

1. Be conversant with and have demonstrated abililties/capabilities for the demands of designing high tolerance composite manufacturing moulds
2. Demonstrated capabilities and experience with the relevant manufacturing processes in order to manufacture the neccessary validation parts.
3. The winning bidder would be expected to provide sufficient hardware and software to meet the needs of a) the primary test objectives described in the scope of work b) all other necessary qualification and test activities that arise.
4. The winning bidder would be expected to provide, at any stage as requested by the Topic Manager, technical documents, drawings and descriptions, including electronic models, of the developed hardware.
5. Ability to support the design of the rotor blades, especially in regards to manufacturability.
6. Experience with industralisation of the chosen processesin order to advise on the production process.
7. Experience in the production of aerospace composite parts.
8. The winning bidder will be expected to be available for meetings at the consortium member's premises in The Netherlands. This cost must be covered by the succesful bidder.

4. Major deliverables and schedule

Deliverable	Title	Short Description (if applicable)	Due date (month)
D0	Receipt of Requirements Specification	Topic manager supplied document at issue 1 and amended thereafter	T_0
D1	Provide Detailed supplier Specification	Detailed supplier specification for the wind tunnel rotor blades in response to D0 explaining how the bidder proposes conducting the work	T_0 + 2 months
D2	Detailed Design Review – DDR - report		T_0 + 5 months
D3	First process testing report		T_0 + 8 months
D4	Tooling for substantiation tests		T_0 + 10 months
D5	Second process testing report		T_0 + 13 months
D6	Critical Design Review – CDR - report		T_0 + 13 months
D7	Production of a prototype manufactured with prepregging and RTM technologies	Review and demonstration of: a) functionality of the moulds b) dimensional requirements of the validation articles are met c) the processing strategy d) consistency of mass of the article produced	T_0 + 14 months
D8	Supply of complete mould systems including modification from lessons learnt from D7		T_0 + 16 months
D9	Final report	Wrap up report including possible routes for the full scale industrialisation and manufacturing of rotor blades	T_0 + 18 months

Note: Aside from these deliverables, the following are part of the scheduling:

- Monthly telecon updates

- Meeting and presentation at the consortium member's premises
    - At kick-off T_0
    - At the PDR and CDR stages, coinciding with D2 and D3 respectively
    - At the review and demonstration stage of D5
    - At the final report stage of D9
- Support with setting up the delivered equipment to enable a fully working system at the consortium member's premises, between T_0 +16 and T_0+18

Definition of terms:	
Chordwise	Dimension through the aerofoil, starting from the blade leading edge ('nose')
Spanwise	Dimension along the length of the blade, usually measured from the blade's centre of rotation
Leading edge	Frontal most point/section of an aerofoil section
Trailing edge	Aft most point/section of an aerofoil section
CF	Centrifugal force
AGF	Active Gurney Flap
GRS	General Requirements Specification
GRC	Green Rotorcraft Consortium
ART	Active Rotor Technology
AGF System	Active Gurney Flap system - all mechanical.electrical and electronic systems to produce a working AGF capability within a model rotor blade and operating on a model rotor test facility with closed loop control.
RTM	Resin Transfer Moulding

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:

€ 400,000 (VAT not applicable)

Four hundred thousand euro

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 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 about 25 pages.

Additional figures of interest:

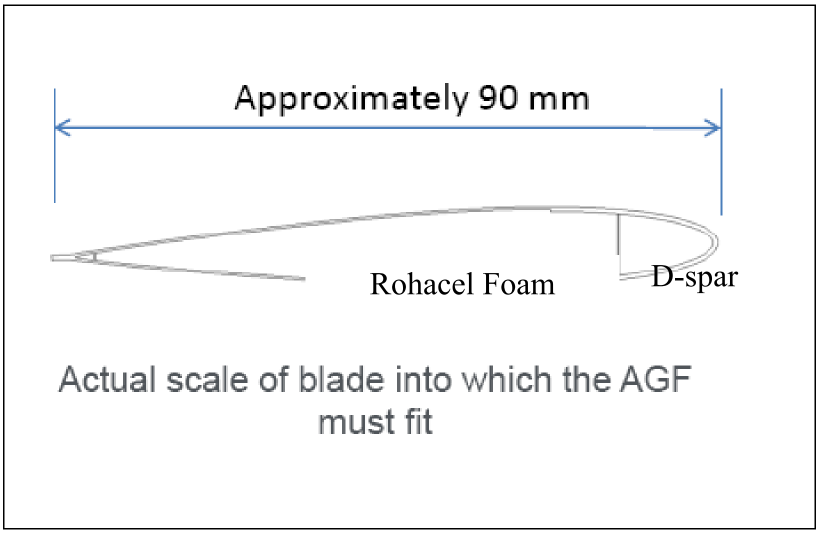


Figure 5: Scale of the blade

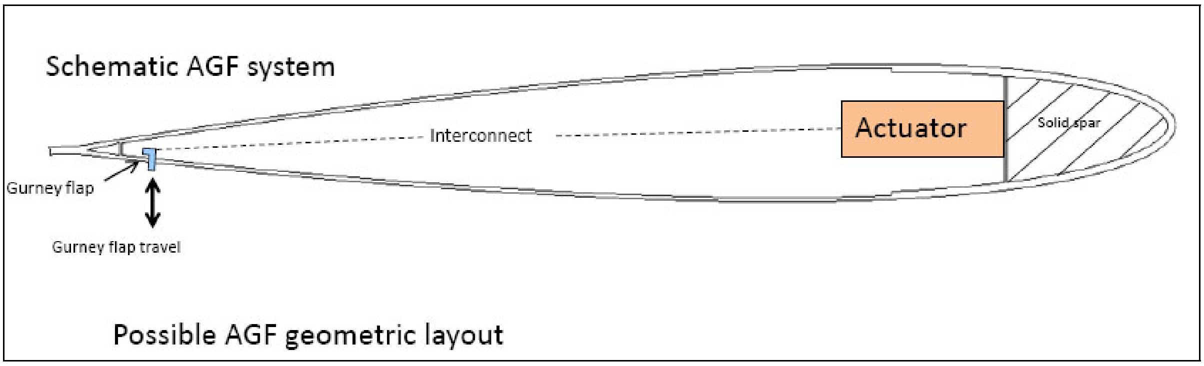


Figure 6 - Possible blade layout for the AGF region

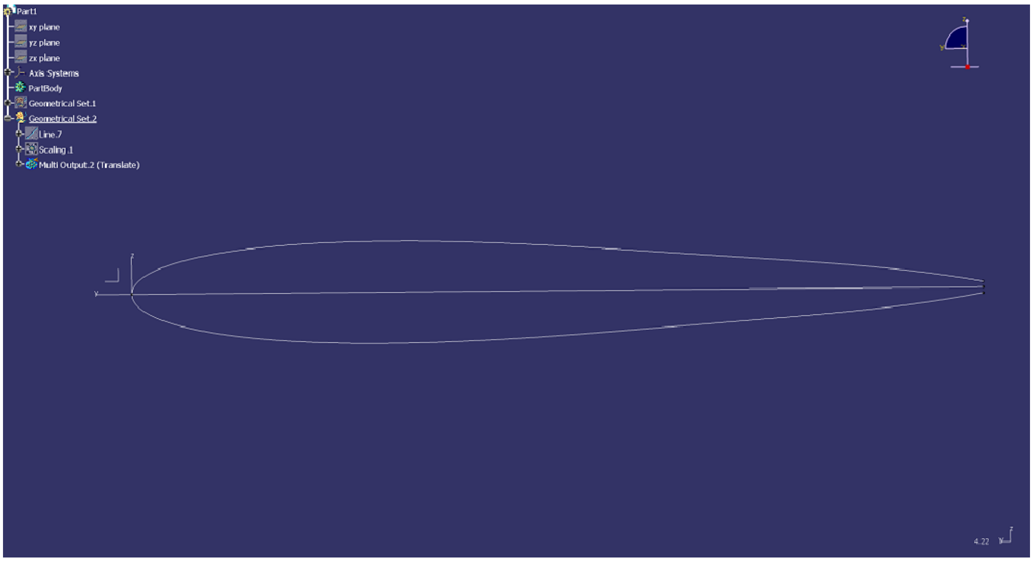


Figure 7 Enlarged trailing edge thickness for the Gurney flap region

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-GRC-03-012	**Development and delivery of EMA for a light helicopter**	**End date**	*28/02/2014*
		Start date	*03/09/2012*

1. Topic Description

Background

One of the JTI "Clean Sky Rotorcraft" objectives, is to reduce the hazardous substances from the atmosphere. The hydraulic liquids consist many of them and cause a danger for World environment. This is a reason to limit them by replacing any devices supplied by hydraulic liquids.

Helicopter flight control system includes hydraulic actuators supplied by liquids. Electromechanical Actuators (EMA) excludes additional devices like hydraulic pomp, distributor, valves, what indeed decrease total weight of helicopter. Weight reduction will contribute to decrease elementary fuel consumption and in consequences air pollution.

Traditional EMA are generally used in helicopter design especially in flight control system to facilitate helicopter flight control system integrations with a flight stabilisation or an autopilot system but like a secondary devices fitted to the control system in parallel.

The new EMAs for light helicopter will fully replace currently used hydraulically driven systems and will facilitate the installation of an auto stabilizer or and AFCS (Automatic Flight Control System) on a light helicopter in the future, making it more attractive for customers and becoming more friendly for environment.

EMA meeting requirements provided in this document does not yet exist and has never been used in such a context.
The research program is needed to properly define new devices that will replace (in competitive manner from both technological and business points of view) the hydraulic actuators.

Scope of Work

The EMA must be developed in such a manner to be able to be installed on a light helicopter that could be flown by pilot inputs via mechanical control links.
The configuration of the actuator should be characterized by low complexity taking advantage of manual operation reversion capability, along with challenging low weight, cost and maintenance targets to make it commercially viable for small aircraft (better than existing hydraulic solutions).
FMEA justifying the proposed configuration must be supplied. The critical performance factor must include instant manual control override recovery from jammed and run-away actuators. The EMA must work without electrical power, which may be common mode failure factor.
The EMA electrical power requirements should be optimized in such a manner to reduce the additional generator supply peak power demand.
Criteria could include actuator with both electronic signal FBW (Fly-by-wire) input as well as a self-contained mode simply acting as force assistance maintaining the pilot control demand position without additional electronic control feedback. Thus allowing development of a common component which can be installed in simple machines, It can also be augmented to provide corrective AFCS stability control.
In the scope of these activities the prototype of EMA must be developed and delivered. The support of EMA integration on a light SW-4 helicopter control system must be guaranteed

Preliminary design information
The current helicopter flight control links must remain without any changes when the EMAs replace the hydraulic actuators. Figure 1 presents the layout of hydraulic actuators in current flight control system.

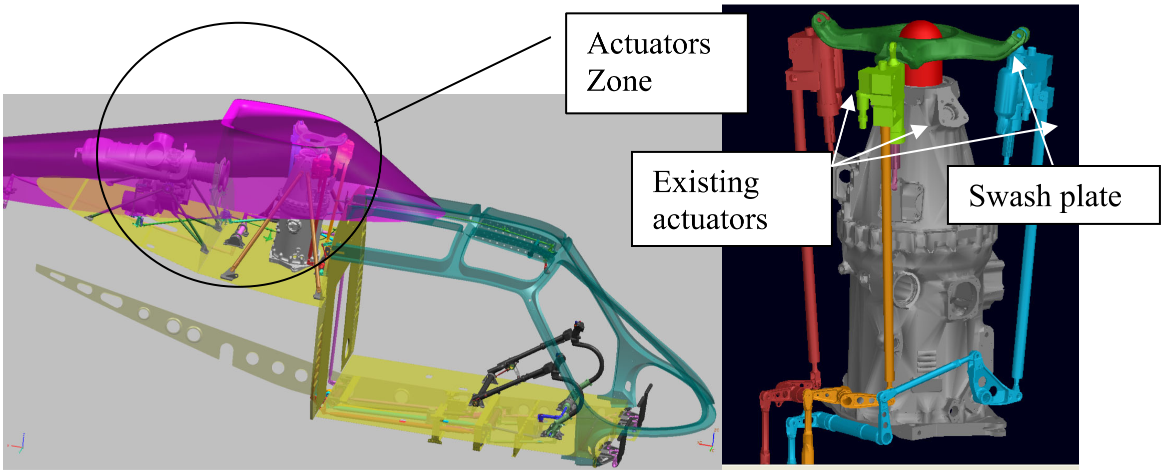


FIG. 1

In term of augmentation flight control system reliability, the EMA system must be equipped with mechanical feed-back devices. This system must allow to manually control flight control chain in case of any electrical/electronic EMA system failure. EMA system design must ensure proper operation in case of internal mechanical or electrical system failures. EMA system must include two independent systems connected by an electromechanical clutch (an innovative solution is required). This clutch must be developed in such a manner to assure the proper disconnection in case of any electrical actuator system malfunction, however, the control of the swash plate must be guaranteed.
In case of failure, the system must be able to recover during operations without any intervention.
Prior the development of EMA, a Failure Mode and Effect Analysis (FMEA) must be carried out. The FMEA must indicate the proper way for EMA development.
The EMA must be irreversible (must fix its position under external loads) and its installation must use the actual interfaces and attachments points for hydraulic actuators (the points will be defined with the Partner at the beginning of project realisation).
The EMA design must meet the JAR 27.683, 681 regulations at least.

EMA preliminary dimensions

Item	Description	Dimension
1.	Minimum length (between centre of bearings)	228 mm
2.	Maximum length (between centre of bearings)	332 mm
3.	Total Stroke (symmetric)	104 mm

All detailed dimensions will be defined with Partner(s) during project execution.
Some dimensions can be modified during 3D design analysis.

Main EMA technical specifications

	Load [N]	Total life [%]
Driving peak	2850	8
Driving stall	2200	10
Holding peak	4150	2,5
Holding stall	3250	2
Ultimate forces	12225	-

Parameter	Unit	Value
Fatigue life time (minimum) for actuated mode	[hour]	3500
Fatigue life time (minimum) for mechanical mode (emergency mode)	[hour]	1000

Time between overhauls (TBO)	[hour]	1500
Position accuracy	[mm]	+/-0,2mm
Total weight	[kg]	<5.5 kg
Outside ambient temperature range	[°C]	- 35 ÷ +80
Reliability for electronics devices	[-]	10^{-5}
Reliability for mechanical elements	[-]	10^{-9}
Electrical supply voltage	[V]	24-28

Limited authority	
Hard-over	±7% of total stroke
Run-away	2.5 mm/s

Driving peak: Displacement *is possible under max force in short time.*

***Driving stall**: Displacement under max force in long duration.*

***Holding peak**: Max force that is possible to hold in short time.*

***Holding stall**: Max force that* is possible to hold in long duration.

Total speed for actuator driving stall is 105< V<145 mm/s.

Speed condition	Speed [mm/s], T=+35
no load	105-145
no load (mechanical load): in retraction direction	≥ 127
in extension direction	≥ -127

Test requirements:

Table shown below includes essential chapters from aviation standard RTC/DO 160 D to be considered during EMA development.

RTC/DO 160 D	
Section	Description
4	Temperature + Altitude
5	Temperature + Vibration
6	Humidity
8	Vibration
12	Sand and dust
13	Fungus resistance
15	EMI effect
22	Lighting indicate transient susceptibility

Tasks:

1. Provide nominal weight analysis
2. Provide power consumption calculation
3. Provide the FMEA
4. Provide strength and fatigue analyses
5. Identify that component competitive commercial cost viability is a critical adoption factor and include guidance on cost targets based on existing examples of hydraulic system
6. Identify and design flexibility requirements: modularity, scalability, supply voltage options,

electrical drive control option,

7. Provide initial assessment at the PDR, leading to design review/technology selection
8. Supply one EMA mock-up (mechanically active) for functional tests on the helicopter
9. Provide design at CDR, including: technical description with interface definitions, 3D models (in NX6 or Catia v5), operational performance characteristics, internal electronic system that record forces, displacements and velocities
10. Laboratory acceptance release test including validation for ground tests (HALT, vibration, thermal).
11. Demonstrate the EMA system recovery in case of an electrical failure.
12. Deliver three brand new EMAs.
13. Support to the demonstration program.

2. Special skills, certification or equipment expected from applicant

1. Master skill of EMA design
2. Catia v.5 or NX6 abilities
3. Good knowledge in EMA software application (programming)
4. Good know-how in EMA for aircraft flight control system use
5. Electromechanical test facilities
6. EMA manufacturing abilities
7. Abilities to certificate the developed EMA according to EASA regulations
8. Experiences in EMA application on an aircraft.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	EMA development (PDR)	- nominal weight analysis - power consumption calculation - FMEA - strength and fatigue analyses - component cost analysis and optimization - 3D preliminary EMA optimized model (-s) description and presentation	T_0+6
D2	One EMA mock-up delivery	Mechanically active one EMA mock-up delivery for functionality checking on H/C	T_0+6
D3	Final design of EMA (CDR)	The design should contains: - nominal weight definition - power consumption definition - 3D model - operational performance characteristics - interface control document	T_0+10
D4	Laboratory test outcomes	- delivery of the test outcomes to the Topic Manager	T_0+14
D5	Manufacturing of three prototypes	- manufacture 3 pcs and delivery to the Topic Manager- the support in EMA integration with H/C demonstrator	T_0+18

4. Topic value (€)

The total value of this work package shall not exceed: **650,000.--€** [Six hundred fifty thousand euro] Please note that VAT is not applicable in the frame of the Clean Sky program

5. Remarks

Flight clearance test outcome is NOT required

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-GRC-06-005	**Recycling of Metallic Materials from Rotorcraft Transmissions**	**End date**	*To + 12*
		Start date	*04-2012*

1. Topic Description

1. Background:

Helicopter power transmissions typically consist of a number of gearboxes which transmit power from the engines to the rotor systems via a series of shafts. Typically this system is primarily manufactured from metals with coatings to enhance surface hardness, lubrication or provide corrosion resistance. These coatings may be metallic, ceramic or polymeric in nature depending upon their function. The whole internal structure then operates in a lubricant product is applied to improve..

The components of the transmission system have a finite life after which they must be withdrawn from service and disposed of. At the end of its service life, each component and the transmissions system as a whole must be returned to the materials market in amanner that is energy efficient and produces the minimum of environmentally sensitive waste product. This means that each part of the transmission assembly (shafts+gearbox) must be recycled within an environmentally friendly manner in order to restore cleanliness of the bulk materials.

The reycling system shall therefore;

- Be capable of removing surface treatments cleanly and with minimum waste product.
- Be capable of recycling the metallic materials to produce raw material of suitable quality for re-use
- Minimise energy consumption in the recycling process
- Use a minimum of substances listed in REACh candidate lists in waste products.

The aim of this CFP is to find a partner/ consorotium to apply modern methods to the recycling process to aerospace materials and processes commonly found in helicopter gearboxes and drivetrains. It is anticipated that the methods of recycling materials are already available and the challenge will be to apply these in a cost effective andway to maximise re-use of material.

2. Scope of work

Each contributing participant will supply to the selected partner/partners details of the demonstrator components and assemblies developed within GRC 6.3 and 6.4 and also trial components where appropriate from these two work packages.

The partner/ consorotium shall apply a recycling method to the two demonstrators of each ITD manager and provide associated detailed analysis.

The partner/ consorotiumshall provide knowledge and experience of the recycling process and appropriate markets.

The partner/ consorotiumshall have, or shall have access to, facilities capable of managing trial components to demonstrate process and costs entailed in the recycling process.

The partner/ consorotiumshall have the ability to measure cost and efficiency of the pocess/processes selected.

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

The applicants shall have knowledge of the recycling industry and shall have specialist knowledge of the chemical and other processes used in recycling metallic components in a clean and energy efficient manner. Expert knowledge of the appropriate markets will be essential.

The applicant shall have or shall have access to, facilities for metallic material recycling. And shall have a demonstrated capability to monitor energy usage and cost during the process.

4. Major deliverables and schedule

Deliverable	Title	Short Description (if applicable)	Due date (month)
D1	Survey of gearbox components and suitability for recycling methods.	Report	To + 3 Months
D2	Detailed description of the dismantling methodology with several steps : 1 - Separate the different parts 2 - Remove the surface treatment 3 - Recycling the materials (with minimized energy consumption)	Report	To + 6 Months
D3	Application of the dismantling methodology	Report	To + 9 Months
D4	Evaluate the cost-effectiveness (operation cost and re-use percentage)	Report	To + 12 Months

5. Topic value (€)

The total value of this work package shall not exceed:

€ 200,000/00

Two hundred thousands euro

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

6. Remarks

The candidates should know that, in case that they are successful, they would have to sign an implementation agreement with several industrial companies which engage the chosen candidate not to disclose to a corporation, the information which have been transmitted by each of the competing companies.

Clean Sky Joint Undertaking
JTI-CS-2012-01-GRC-06-006

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-GRC-06-006	**Disassembly of eco-designed helicopter demonstrators**	**End date**	T0 + 18 months
		Start date	T0 = Sept 2012

1. Topic Description

Background:

The objective of CleanSky Green RotorCraft 6 is to design and manufacture rotorcraft demonstrators, such as airframe and transmission parts, by using eco-efficient materials and processes.

The goal is to achieve a cost and weight saving compared to today's solutions by integrated design and reduced number of manufacturing steps (including assembly, surface finishing, reduced re-work, recyclable products) and by being easy to separate components (dis-assemble)for recycling and possible re-use.

The demonstrators are based on airframe structures made out of recyclable thermoplastic composites.

Examples for thermoplastic composite structures are helicopter doors, (stiffened) skins, stringers and fittings. The thermoplastic composites consist largely of carbon fibre reinforced PEI, PPS, PEEK or PEKK and combinations with other materials, such as metal attachment parts, polymer windows, sandwich cores, thermoset repair patches, are possible.

The main goal of this Call is to investigate and evaluate different technology concepts for separation of thermoplastic composite demonstrator components, such that they can thereafter be recycled or re-used. The demonstrator components are joined to thermoset as well as thermoplastic composite (TPC) and metal components. The joint areas are manufactured using riveting (metal to composite), welding (TPC to TPC), and adhesive bonding (TSC to metal, TSC to TSC).

The aim is to realise and demonstrate the most promising technologies on selected demonstrator parts, which will be made available to the applicant. A qualitative analysis considering component separation of such helicopter elements based on thermoplastic composites and junctions have to be executed, including verifying environmental aspects, cost analysis and supply of quantitative input for the life cycle assessment (LCA) tool. Examples of data are energy consumption, waste, dust generation, use of ancillary materials, etc. Guidelines as to the collection of data for the LCA tool will be provided by the topic manager.

In other words, an assessment shall be made of the possibilities for component separation technologies and the impact on the total demonstrator life cycle. An evaluation based on ecological impact, as well as cost should provide the most favourable technology. Inputs should be provided to the design stage where possible.

Scope of work:

The applicant is responsible for the following tasks:

- Collect and assess possible component separation scenarios for particular helicopter structures based on thermoplastic composite materials and junctions, leading to preferred scenarios. This task has to be carried out by considering that there are different demonstrator activities in parallel (based on thermoplastic technologies), which are independently developed by different company groups.
- Investigate the quality of the separate component, to assess the component and waste quality, such that input for a 'waste' or 'second-hand component' catalogue can be made available.
- Investigate the design influence on the solutions for component separation, and provide design recommendations.
- Demonstrate and define with the cooperating companies a component separation plan and carry out demonstration activities for the most meaningful separation processes.
- Collect and provide input for the Life Cycle Assessment tool

Below, an overview is given on the selected demonstrators to define the work volume and help the applicants to answer to the call for proposal.

Note: The demonstrators will be manufactured and provided by the industry partner.

GRC6.1.5: Thermoplastic composite pilot door structure

The door demonstrator will be based on structural thermoplastic composites with either PPS (polyphenylene sulphide), PEI (Polyether Imide), or PES (Polyethersulfone) matrix and continuous carbon fibres.

GRC6.2.5: Demonstrators for Thermoplastic Structural Parts

Thermoplastics reinforced with carbon fibres can be used in primary structures.

The reference parts consist of a rear upper panel, fuselage sponson fairing and radome.

Work package	Part	Weight (g)	Materials/ technology
WP6.1.5	Door frame	~3000	Continuous carbon fibre reinforced thermoplastics (CFRP)
	Window	~500	Thermoplastic
	Attachment parts		Metal, … (optional)
WP6.2.5	Skins		CFRP Thermoplastic laminates
	Stringers/Longerons		CFRP Thermoplastic laminates
	Attachment parts		Metal, … (optional)

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

The applicant (single organisation or a consortium) should include research laboratories, institutes and/ or companies having the following facilities and knowledges:

- Strong knowledge on aerospace materials (CFRP with thermoplastic as well as thermoset matrices)
- Extensive experience and capabilities for joining and disassemblyof thermoplastic composite components and their joints.
- Experience and capabilities for collecting data that serve as input for a life cycle assessment tool.

3. Major deliverables and schedule

Deliverable	Title	Short Description (if applicable)	Due date (month)
D1	Concerted plan for disassembly demonstration activity	Report with accurate definition on the disassembly activity based on consultation of the different actors	T0 + 2 (months)
D2	Feasibility demonstration for composite structures	Experimental proof of ecological and economical feasibility of selected component separation technologies	T0 + 12
D3	Disassembly technology demonstration report on TPC demonstrators	Report with results of demonstration of disassembly technologies on TPC composite demonstrators	T0 + 18
D4	Software file with input for life-cycle-assessment tool		T0 + 18

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:

€ 200 000.00 (VAT not applicable)

Two 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 candidates should know that, in case that they are successful, they would have to sign an implementation agreement with several industrial companies with a binding commitment to protect confidentiality of their own proprietary data.
- *The expected length of the technical proposal is about 20 pages*.

Clean Sky – Sustainable and Green Engines

Identification	ITD - AREA - TOPIC	topics	VALUE	MAX FUND
JTI-CS-SAGE	**Clean Sky - Sustainable and Green Engines**	**11**	**16.150.000**	**12.112.500**
JTI-CS-SAGE-01	*Area-01 - Open Rotor Demo 1*			
JTI-CS-SAGE-02	*Area-02 - Open Rotor Demo 2*		**13.150.000**	
JTI-CS-2012-1-SAGE-02-011	Pitch Change Mechanism development, test and supply for engine demonstrator		7.000.000	
JTI-CS-2012-1-SAGE-02-012	Optimal High Lift Turbine Blade Aero-Mechanical Design		850.000	
JTI-CS-2012-1-SAGE-02-013	Advanced Non Destructive Testing methods and equipment development for fabricated structures.		500.000	
JTI-CS-2012-1-SAGE-02-014	Enhanced material and lifing model including sustained peak Low Cycle Fatigue		900.000	
JTI-CS-2012-1-SAGE-02-015	Advanced electrical machine manufacturing process implementation and tuning based on composite material process		200.000	
JTI-CS-2012-1-SAGE-02-016	Study and durability of electrical insulating material in aircraft engine chemical environment		200.000	
JTI-CS-2012-1-SAGE-02-017	Variable thickness lamination machine-tool design and manufacturing		500.000	
JTI-CS-2012-1-SAGE-02-018	Engine Mounting System and Engine In-flight Balancing System		3.000.000	
JTI-CS-SAGE-03	*Area-03 - Large 3-shaft turbofan*		**2.600.000**	
JTI-CS-2012-1-SAGE-03-012	Non-metallic Pipes for Aero engine Dressings		1.800.000	
JTI-CS-2012-1-SAGE-03-013	Extended operation temperature range for compressor structure materials		800.000	
JTI-CS-SAGE-04	*Area-04 - Geared Turbofan*			
JTI-CS-SAGE-05	*Area-05 - Turboshaft*		**400.000**	
JTI-CS-2012-1-SAGE-05-016	Telemetric System Acquisition in harsh Environment		400.000	

Clean Sky Joint Undertaking
JTI-CS-2012-01-SAGE-02-011

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-SAGE-02-011	**Pitch Change Mechanism development, test and supply for engine demonstrator**	**Start date**	*01/10/2012*
		End date	*20/12/2015*

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 CROR engine architecture is a challenge for the **Pitch Change Mechanisms (PCM).**

During concept analysis, several PCM candidates have been studied and a preliminary dowselection made with a special focus on reliability aspects.

To garantee the performances of downselected concept, and mitigate technological risks relative to engine demonstrator and target engine application in term of technology maturity, a second step has been launched in 2011 to design key components and run endurance tests.

PCM architecture for the engine demonstrator is now frozen and procurement of the dedicated PCM is required. As the engine is made of 2 propellers, 2 different PCM sets are required: one for each row.

PCM technical perimeter:

- Oil Transfer Bearing allowing oil transfer between static frame and rotating frame for PCM operation (and potentially some engine bearings lubrication)
- PCM hydraulic actuators including position sensors and min pitch flight stop devices
- PCM mechanism between PCM actuator and blade root, including radial shaft bearings and seals

Models:

- Model delivery will be required during design phase for integration into engine model: CAD modelsand functionnal models

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

Required tests before PCM delivery to the engine demonstrator build up:

- preliminary list of tests (but not exhaustive) to be conducted on applicant site includes:
  - PCM mechanism overspeed test
  - PCM mechanism functionnal test including preliminary integration with Snecma designed control loop.

Scope of call for proposal:

- detailed design of SAGE2 demonstrator PCM components based on specification defined by Snecma, consistent with PCM architecture downselected during the previous concept phase
- manufacturing and/or procurement of PCM components
- detailed design of test bench required to verify PCM before delivery to engine build up, based on quality requirements agreed with Snecma (refer to preliminary list above)..
- manufacturing and/or procurement of components for PCM test bench
- design, procurement and implementation of instrumentation required for the different tests on applicant site in addition to engine tests on ground and possibly future test in flight

- PCM test bench design, modifications and commissionning including test bench control and instrumentation
- PCM tests required to clear delivery to engine assembly, based on quality requirements agreed with Snecma (refer to preliminary list above).
- Support for integration tests conducted on PCM test bench between PCM and engine control system provided by Snecma
- Support for engine tests on engine test site including PCM measurement data analysis and trouble shooting
- PCM components modeling (for integration into the engine model driven by Snecma: CAD model and functional simulation)
- Management and reporting activities related to the technical activities listed above including contribution to demonstrator technical reviews
- Co-located activities on Snecma site for short periods of time during engine detailed design phase in order to facilitate PCM integration and interface management with program partners.

To secure engine tests, spare parts will be required to cope for potential failure during verification and/or integration and/or engine tests. Number of spare parts will be defined in accordance with Snecma depending on each component criticity.

Quality requirements for delivered parts will be “flight worthy” as Open rotor demonstration engine is likely to be tested in flight without re-furbishing

Applicants will have access to PCM requirements and engine integration constraints after signing an NDA with Snecma.

Experience in design, manufacturing and certification of Pitch Change Mechanismsor similar technologies for aircarft engines is mandatory

Experience in test bench design and modification is mandatory

Availability of test benches to support test campaignsis mandatory

English langage in mandatory

Activities shall be conducted using ISO standards

3. Major deliverables and schedule

Estimated project start: T0 = October 1st 2012

Deliverable	Title	Description (if applicable)	Due date
D1	Development plan	Including detailed risk analysis and mitigation proposal	T0 + 1 month
D2	PCM Components and test bench preliminary Design review	Preliminary design review	T0 + 3 months
D3	PCM Components, instrumentation& test bench detailed Design	Critical Design Review	T0 + 14 months
D4	PCM components, instrumentation & test bench ready to test	Test Readiness Review	T0 + 23months
D5	PCM components& instrumentation ready for engine delivery	Acceptation review	T0 + 27 months
D6	Final conclusions	Closure report	T0 + 39 months

4. Topic value (€)

7,000,000 € **Seven Millions euro** including company own funding & JU subvention 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

Regular phone call meetings (weekly basis) will be held with SNECMA to deal with technical and program questions. *Face to face workshops will be organized approximately every 4 months on Snecma site and/or on test bench site*

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-SAGE-02-012	**Optimal High Lift Turbine Blade Aero-Mechanical Design**	**Start date**	*T0*
		End date	*T0+18M*

1. Topic Description

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

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

Components and modules with innovative characteristics, for this new configuration, have to be developed, implemented and validated through rig testing as required before the integration into the SAGE2 demonstrator. The successful validation of these technologies will facilitate the early introduction of this innovative aircraft engine concept into the market, and significantly reduce the environmental impact of air transport.

In order to answer the needs of the SAGE2 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 advanced aerofoil design and technologies for high speed configurations with high performance and compliant mechanical stresses characteristics.

The overall aim of this Call for Proposal is to use Multi-Disciplinary design approaches and state-of-the-art design tools to define an optimal aero solution for high speed aerofoil blades capable to guarantee stresses compliant with standard aeronautical materials used for these engine parts.

High Speed Profiles are characterised by very high hub stresses and a new aerodynamic definition for the aerofoil is therefore needed in order to minimize these values without a too detrimental effect on performance. Mainly three possibilities to reduce these stresses have been identified and could be adopted in the optimal solution:

- Reduced Turbine Height. This solution reduces the weight of the rotational part but also the area in which the flow is evolving increasing axial Mach Numbers and then also the profile losses.

- Increased Hub over Tip Area Ratio acting on hub aerofoil thickness. This solution increases the resistance capability of hub sections but is limited by weight increase (specific hardware solution is then to study specific solution e.g. hollow aerofoils) and by local Mach number increase. A detailed aerodynamic optimization is therefore required.

- Increased Axial Chord Tapering. This solution, as the previous one, increase the resistance of hub section but at the same time it has an impact on wetted area, and consequentially on the friction losses, decreasing the overall profile performance. This problem is then requiring a specific aero optimization to understand which kind of aerofoil solution is preferable for this very peculiar design (different from standard aeronautical used profiles).

Optimal High Speed rotor aerofoil design could be a compromised solution of the three suggestions above reported or a new proposal able to solve identified aero-mechanical problems. However the identified solution will have to fulfil the following requirements, assuming that specific prerequisites on weight and overall dimension are satisfied:

Requirement 1: High aerodynamic performance

High speed turbines are high performance modules thanks generally to low stage loading coefficients and high values for rows Aspect Ratios. But these configurations have to deal with high level of outlet Mach number for the rows (tied to an increased stage Pressure Ratio and higher axial flow velocities).

Also, as reported in above descriptions, mechanical stresses requires specific hub section aerofoil design and this could imply a local strong increase of aerofoil velocities with local supersonic regions that should be avoided in order to contain losses. A high increment of losses, even focused on a specific location, could have a major detrimental impact on module performance and then it has to be avoided adopting specific optimized solutions.

The final proposed solution should be validated and verified experimentally from aero point of view. An overall module impact of the proposed solution should be finally carried out and compared with the baseline aero design.

Requirement 2: Low Mechanical Stresses

High Speed Turbines are characterized by high centrifugal loads on Blade aerofoils. A standard 3D LPT aerofoil shape wouldn't allow obtaining aerofoil compliant with typical turbine materials capabilities.

The final proposed solution should include an optimized aerofoil design with peak stresses inside turbine materials capabilities validated with detailed numerical analyses.

Requirement 3: Minimal aerofoil thickness respected

The final proposed solution should be optimized from a manufacturing point of view, taking into account minimum thickness and span-wise thickness distributions compliant with both casting and machining state of the art capability.

Final requested values for allowable delta module efficiency, maximal blade stress and minimum adoptable aerofoil thicknesses will be provided by Avio at the beginning of the project.

The proposal of the applicant has to include a description of a solid approach to develop the future high speed rotor profile definition following the given requirements.

Task 1: Management

Organisation:

- The partner(s) shall nominate a team dedicated to the project and should inform Avio S.p.A. project manager about the names of this key staff. At least the responsibility of the following functions shall be clearly defined: Program (single point contact with Avio S.p.A.), Numerical and Experimental Technicians.

Time Schedule & Workpackage Description:

- A detailed time-schedule and work-package description shall be detailed as required and agreed at the beginning of the project.

Progress Reporting & Reviews:

- Quarterly written progress reports shall be provided by the partner(s), referring to all agreed work-packages, technical achievement, time schedule, potential risks and proposal for risk mitigation;
- Regular coordination meetings (biweekly) shall be carried out (preferred by teleconference) to

verify advancements on program time-schedule;
- The partner(s) 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 AVIO S.p.A. facility.

Task 2: Aerofoil optimization for rotor high speed blades

- The partner(s) shall study and evaluate the performance of the Avio S.p.A. proposed baseline aerodynamic solution identifying main aero-mechanical characteristics and problems;
- A specific optimization should be done by the partner(s) to define one or more optimal aero-mechanical solutions (to be later tested and validated experimentally) representing a good compromise between opposite aero-mechanical objectives and in line with above requirements;
- Proposed solution will have to be evaluated by the partner(s) in terms of mechanical characteristics, row performance and impact on overall module efficiency.

Task 3: Experimental tests design and hardware procurement

- The partner(s) shall prepare experimental tests defining cycle scaling, test matrix and hardware (including profiles to be tested) to later perform tests capable to reach project objectives;
- The partner(s) shall develop a measurement planning aimed at investigating and validating the aerodynamic performance of the adopted innovative blades;
- The partner(s) shall prepare the test rig with the necessary hardware components and measurement instrumentation.

Task 4: Experimental test esecution

- The partner(s) shall set up a laboratory test stand which is adequate for the measurements of the innovative blades performance, as well as of the flow within the blade rows;
- The measurement techniques adopted should allow detailed results, in order to achieve an accurate evaluation of the different innovative blades performance;
- Experimental investigations should be carried out upstream and downstream of the rotor blade rows;
- The partner(s) shall validate the functionality and accuracy of the measurement system within the laboratory test set-up.

Task 5: Experimental-Numerical Comparison and final design validation

- Detailed description of numerical analyses has to be reported with particular details to highlight final optimized solution and comparisons with baseline aero proposal by Avio (for aerodynamics and mechanical characteristics);
- Extensive summary of experimental results and comparison with numerical prediction should also be reported with a final validation of proposed solution.

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

The applicant has to be a University or a University consortium with several year experience in the field of aerodynamics of turbomachinery for aeroengine application.

The applicant should have:

- both experimental and numerical experiences for the analysis of complex unsteady flows within aeronautical low pressure turbines;
- experience in CFD for the detailed analysis of steady flows and of components interaction in unsteady multistage environments (URANS); experience in geometries parameterization and multi-objective optimization of blade rows;
- experience in the design and operation of experimental facilities for aeronautical engine investigations, such as wind tunnels and turbine research models;

- an existing facility which could be easily adapted to perform the tests for the validation of innovative blades performance;
- advanced instrumentations which allow experimental measurements in both time and frequency domains, as well as the evaluation of power density spectra of the row signals, and phase-locked acquisitions;
- experience in measuring flow within turbomachinery rotors, as well as in measuring flow turbulence, boundary layers and blade wakes;
- experience in the signal post-processing for the analysis of viscous unsteady fluid flows, including knowledge in the ensemble averaged phase-locked acquisition procedure;
- existing experience in at least some of the project topics, e.g. analysis of unsteady flow within low pressure turbines, study of the aerodynamic performance of LPT blades, prediction of separation-induced transition in high-lift aerofoils and wake-induced transition in multistage environments;
- existing experience in collaborative European research projects in the field of aeroengine turbine aerodynamics.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Detailed Project Plan	Schedule with milestones, technical specification of experimental system	T0+1M
D2	Profile optimization study report and baseline (only aerodynamic optimization) experimental profiles definition	Description of aero-mechanical optimization concept study and preparation of baseline (only aerodynamic) profile for test	T0+6M
D3	Test on Baseline profile	Experimental results on baseline profile	T0+12M
D4	Aero-mechanical profiles optimization and experimental solution definition	Description of numerical results on the aero-mechanical optimized profiles and test preparation for optimized configuration	T0+12M
D5	Test on aero-mechanical optimized profiles	Experimental results on aero-mechanical optimized profiles	T0+16M
D6	Numerical-Experimental comparison and final project report	Description of numerical experimental comparison and final consideration on optimized aero-mechanical high speed profile	T0+18M

4. Topic value (€)

850,000 €
Eight hundred 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.

5. Remarks

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

Clean Sky Joint Undertaking
JTI-CS-2012-01-SAGE-02-013

Topic Description

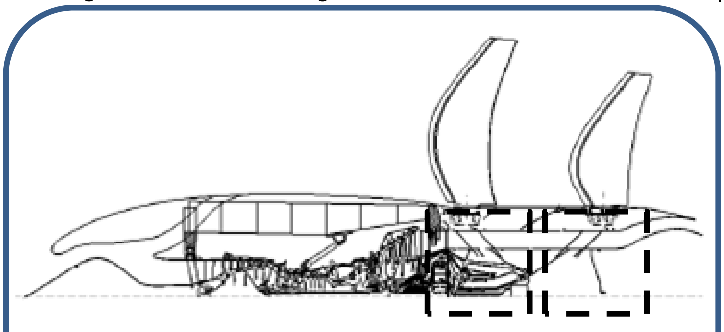
CfP topic number	Title		
JTI-CS-2012-01-SAGE-02-013	**Advanced Non Destructive Testing methods and equipment development for fabricated structures.**	**Start date**	*01/09/2012*
		End date	*31/05/2015*

1. Topic Description

The SAGE project aims at demonstration of engines and technologies to reduce fuel consumtion, weight and increased efficiency of engine components.

Within the objectives of 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).



Rotating frames in an open rotor engine

In order to accomplish the future targets of effective, cost efficient and reliable open rotor engines, manufacturing and maintenance issues need to be adressed and optimized, and this put greater demands on the non-destructive techniques (NDT) used for flaw detection. This applies in particular to the rotating propeller frames in open rotor engines and the requirements for NDT and inspection of welded parts on this component type.

In fabricated components and structures (Fabricated components are components assembled from smaller sub-components in mixed material forms preferably joined together by welding), different inspection and NDT methods are being used for weld inspection. The reliable detection of defects (cracks, pores etc.) and inspection of weld geometry (surface, root, penetration etc.) are critical with respect to component life and flight safety. Current techniques such as Visual Inspection, Fluorescent Penetrant Inspection (FPI) and Radiography have limitations in applicability and detectability and may thus reduce the design freedom which may result in a poorer and possibly heavier component.

In the case of rotating frames, the areas that have to be inspected can be difficult to access due to the geometrical complexity and small dimensions compared to the inspection equipment, e.g. interior weld inspection of vanes, and there is a need for new and improved inspection and NDT techniques allowing interior inspection of components.

Scope of call for proposal:

Optical and Infrared inspection & NDT on welds with limited access.

This project proposal addresses the need for new and improved methods for visual inspection, measurement and NDT on welded components with limited access, both in manufacturing and maintenance.

Non-contact techniques such as optical, infrared camera and other with potential for miniaturization and automated measurement and evaluation have to be developed and its capability characterized.

For cases where interior inspection is not possible, but inspection has to be made from the outside of the part, novel measurement and NDT techniques for detection of sub-surface defects and weld characterization needs to be developed and applied.

The Partner shall in particular perform the following tasks:

(Input: Inspection requirements, NDT requirement, access,….)

Task 1 Evaluation of novel inspection techniques

The aim of the task is to study and evaluate possible methods and techniques for inspection of welds with limited access. Method to be evaluated is at least optical (shearography) and IR techniques (thermography). Comparison with traditional NDT-techniques will also be included in the task. Selection of inspection technique will be the output of the task as well as a milestone and a deliverable to the project.

Task 2 Development of novel methods

The aim of the task is to develop the NDT methods suitable for the application in the project. The task includes studying the possibilities of miniaturization of the techniques. The task also aims to develop analysis methods to be able to detect, position and classify flaws in an automatic inspection cell. For both shearography and thermography a well-defined excitation of the structure is needed for reliable results. This task includes also development of suitable excitation for the selected methods. The deliverable from the task, as well as a milestone in the project, is a suggested automatic analyse method to be use in an automatic inspection cell.

Task 3 Capability of selected method

The aim of the task is to study the capability of the selected method. Evaluation of detectability of different defects (types, size and position) will be performed. The output of the task is the capability of the selected method as is one deliverable to the project.

Task 4 Scanning inspection

For improvement of inspection techniques in production, the possibility of automation is essential. The aim of this task is to define the potential for the selected method to be used in automatic inspection. This task is to be performed in parallel with task 1 and 2. Development of robotization of the selected technique, including the excitation, is also included in the task. The deliverable from the task is a solution to scan an entire weld with about 30 cm in length.

Task 5 Automation of inspection method

The aim of the task is to present the possibilities of an automatic inspection technique. That is to show the possibility to inspect an aero-engine component in an inspection cell based on the selected method. The output of the task, is a milestone and a deliverable to the project is a solution of an automatic inspection cell.

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

Extensive experience in the field of advanced measurements and non-destructive testing
Extensive experience in the field of optical and Infrared measurement techniques
Availability of facilities, lab resources and equipment development work in the areas above
Successful experience in leading and managing of research and development programs
English language is mandatory

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1.1	Inspection technique selected	An inspection technique suitable for inspection of welds with limited access is evaluated and selected.	M12
D2.1	Analysis method	A method for automatic analysis of flaw detection is presented.	M24
D4.1	Scanning inspection	A solution to scan a continuous weld with a length of 300 mm is presented.	M24
D3.1	Capability shown	The capability of the selected method is shown with respect to defect types, size, position and geometrical accessibility.	M28
D5.1	Definition of inspection cell	A description of an inspection cell based on the selected inspection method is presented.	M30

4. Topic value (€)

500,000 € Five hundred thousand Euro

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-SAGE-02-014	**Enhanced material and lifing model including sustained peak Low Cycle Fatigue**	**End date**	*2015 04 01*
		Start date	*2012 09 01*

1. Topic Description

The SAGE project aims at demonstrating open rotor engines and technologies to reduce fuel consumtion, weight and increased efficiency of engine components.

Within the objectives of open rotor development in SAGE2, RTD activities are underway on engine and component development including a rear rotating turbine frame.

The rotating frames developed within the SAGE2 project can be considered as engine critical parts, and therfore 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).

The engine operating conditions, thermal and mechanical loads, material properties and other influencing parameters are affecting the Approved Life of the component, and extensive anlysis, component & engine tests, and inspection (during component manufacturing and in-service) have to be performed for verification.

In particular, the regulations required for critical parts to fulfil appropriate damage tolerance criteria has to be considered, and the potential for failure from material, manufacturing and service induced anomalies within the Approved Life of the part. This means that the potential existence of various imperfections, defects and flaws in the component are recognized and are due to material issues, component design and manufacturing. This situation can be handled through the incorporation of fracture resistant design, process control and Non-destructive Testing (NDT).

In order to accomplish the future targets of effective, cost efficient and reliable open rotor engines, manufacturing and maintenance issues need to be adressed and optimized, and this put greater demands on the fatigue analysis methods.

In fabricated components and structures (Fabricatied components are components assembled from smaller sub-components in mixed material forms preferably joined together by welding), different visual inspection and NDT methods are being used for weld inspection. In short, the quality of the welds will determine the fatigue life of a component.

The main focus will be on laser welds on IN718 sheet, but also TIG welds will be included in the project. The material, welding, heat treatment and NDT will be supplied by the Topic Manager but specimen manufacturing is to be carried out within the project.

The project involves three areas and are divided into three tasks (1-3). Tasks 1 & 3 are strongly related but task 2 is more stand alone but demed necessary to cover the scope of fatigue of welds at high temepratures.

1. Defect characterisation and geometry description of weldments
2. Impact of material microstructure on sustained load sensitivity to crack propagation
3. Modelling of LCF/HCF on welded IN718 sheet material

<u>Task 1 Defect characterisation of welded IN718 sheet material</u>

The scope of the projct proposal is to investigate the occurance of defects in welds on IN718 sheet material. The defects are here assumed to be generated during the welding process.

A common approach is to assume that defects always are present in welds and the initial crack size to use for life calculations is determined by the capabilities of the NDT-methods used. This methodology is useful and simple but possibly too simple for advanced fabricated structures where weight is pushed to a bare minimum. For example, low stresses in thin structures with large cracks compared to the material thickness result in short LCF life. Further the current approach limits the design varialbles such as the possibility of inspecting welds.

The proposal covers two aspects, the possibility of defects not possible to handle with initiation type methods and the situation where no defects are present. The first question relates to all types of defects in welds such as pores, micro cracks, lack of fusion etc. Two possible ways to gather the defect population is available; NDT and various destructive fatigue testing methods. Previous material testing shows that not always will a known defect lead to the dominating crack causing a failure but a crack can be initiated for other reasons. Therefore the NDT information may not be sufficient to provide applicable defect distributions. The suggestion is therefore to also do detructive testing meaning HCF/LCF testing and via SEM investigations determine the size and position of the defect causing final failure. A correlation between the NDT determined defects and the defects from fracthography will provide information regarding NDT capability of determining critical defects in welded IN718 sheet material.

Task 2 Impact of material microstructure on sustained load sensitivity to crack propagationThe scope is to investigate the sustained load crack growth in welded Inconel 718 sheet material at elevated temperatures to support design, manufacturing and lifing analysis of rotating frames.

Superalloys such as Inconel 718 in fine grained forms, such as sheets, plates and forgings, are known to be very sensitive to sustained tensile loads at elevated temperatures (T>450°C), where the crack growth rate increases dramatically due to interactions between the environment and the loading of the crack tip. Such material can, on the other hand, to a very large extent be considered as defect-free which reduces the impact of sustained load cracking as there are virtually no cracks present.

Previous testing has indicated that castings are much less sensitive to sustained load cracking. The sustained load crack growth phenomenon is believed to be a grain boundary related phenomenon and the grain boundaries in forgings and castings are different in nature which may explain the differences in sensitivity to sustained load cracking. Welds are less investigated than castings and forgings. Therefore the complicated substructure in weldings need attention. Further welds and castings there is a much higher risk of encountering cracks and defects from processing than forgings.

If sheets are welded together in a high temperature component subjected to sustained peak loading the worst case scenario is that a crack in the weld or heat affected zone (HAZ) will grow into the fine grained base sheet material where accelerated cracking can occur. The purpose is to characterize sustained load crack growth in welded Inconel 718 sheets by mechanical testing and microstructural investigations.

The mechanical testing will produce data regarding the propagation of cracks under sustained load and under creep-fatigue conditions (cyclic loading with peak dwell). Cracks will be artificially initiated at specified locations (e.g. in the weld, at the weld root and in the HAZ) and propagated in controlled testing with simultaneous recording of crack length. The tests will be interrupted to allow analysis of the crack paths and determine the influence of local microstructure.

Additionally, dedicated tests on model specimens with tailored microstructures will allow investigation of the effects of specific microstructural features on the cracking growth. Such features can be controlled by processing and may be used to enhance the resistance to sustained load cracking in service. Task 3 LCF/HCF modelling of welded IN718 sheet

Life and strength models can be based on either initiation type models or fracture mechanics type models. Both approaches has benefits and drawbacks. It is fairly safe to say that the fracture mechanics based modelling is the safe option. The fracture mechanics models are, in short, based on standard crack propagation methods and the initial defect is derived from NDT. Implicitly it is therefore assumed that at every location in the weld cracks are present but the NDT method will not miss a defect of a certain size associated with some probability. The method is reasonable if the material is known to include a large number of defects. However, no benefit is obtained if the combination of material and welding process results in virtually no defects, the NDT method can not distinguish between the two cases. It is also plausible that defects are occuring rarely but not too rarely to be completely ignored. Currently all options are possible. The modelling approach to distinguish between relevance of defects need a great deal of statistical treatment. In the end, a completely statistical approach is prefferred however practical problems such as input to the models are scarse at best. The input from task 1 and 2 will shed light on the necessary input to the models and be used to improve current fatigue models.

Therefore the modelling work will assume existing models i.e. a fracture mechanics approach in conjunction with defect distributions from Task 1 above.

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

The partner/consortium must be able to handle a large volume of fatigue testing at a efficiently.

The partner/consortium must have experience of sustained load crack growth testing using potential drop measurements and equipment to perform high temperature sustained load testing for long time periods as well as creep-fatigue testing with long hold times.

Preferably the partner can offer possibility of testing in controlled environment (controlled oxygen pressure, alternative gaseous environments, vacuum etc.).

The partner/consortium need equipment and experience on fractography using SEM or other appropriate equipment.

The partner/consortium must have appropriate equipment and experience on advanced microscopy techniques (e.g. SEM, FIB/SEM, EDX, EBSD etc.) and microstructural characterization of superalloys.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
1	Preparation of test specimens and NDE evaluation	Separate test specimens for task 1 and 2	M6
2	Fatigue testing	Fatigue testing, task 1 & 2	M18
3	Fractography	Task 1	M24
4	Microscopy	Task 2	M24
5	Lab report and analysis of obtained results from fatigue testing	Task 1 & 2	M24
6	Validation testing	Task 3 Based on results from Deliverable 5 , appropriate model is selected	M26
7	Final report	Task 1, 2 & 3	M30

4. Topic value (€)

900,000 €
Nine hundred thousand Euro

Clean Sky Joint Undertaking
JTI-CS-2012-01-SAGE-02-015

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-SAGE-02-015	**Advanced electrical machine manufacturing process implementation and tuning based on composite material process technologies**	**Start date** **End date**	*Sept 2012* *Dec 2015*

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. Nevertheless, whatever the system design, this electrical machine can be consider as a complex assembly of enamelled winding insulated from a magnetic core by layers of fiber glass reinforced thermoset resin composite, finnally encapsulated with a high dielectric thermoset resin.

This topic aims to develop an optimised manufacturing process for the Open-Rotor demonstrator decing system electrical machine based on organic matrix composite material processing technologies.

The partner shall perform 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 electrical machine manufacturing process
Summarise electrical machine process solutions used in the electrical industry. This state-of-the-art shall emphasis the failure mode that are related to processing problems.
Task 3: Manufacturing process design and resin selection
Design the electrical machine manufacturing process. The process shall be described in a document summarising the successive manufacturing process stage.
Specify and select an impregnation resin to meet with the manufacturing process requirement.
Task 4: Resin process parameters optimisation and testing
Optimisation of the resin process parameters: time and temperature optimisation to obtain the best performances for the selected resin chemistry.
Environmental test on resin samples.
Task 5: Material interface optimisation and testing
Interface adherence optimisation.
Interface durability testing in harsh environment
Task 6: Electrical machine manufacturing
Manufacure a small serie of electrical machine using the previously defined manufacturing process
Manufacturing defect investigation
Overall projet reporting

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 the field of material testing and characterization

Experience in organic matrix composite material processing

The applicant should have at disposal equipements and test means for organic matrix composite material processing and characterisation at high temperature

English language is mandatory

3. Major deliverables and schedule

	2012		2013				2014				2015	
	Q3	Q4	Q1	Q2	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Task 1												
Task 2												
Task 3												
Task 4												
Task 5												
Task 6												

Deliverable	Title	Description (if applicable)	Due date
D1-x	Monthly progress reports		Every month
D2-1	Report on the state of the art		Dec 2012
D3-1	Candidate material selection – first issue		March 2013
D3-2	Material and manufacturing process selection report		June 2013
D4-1	Resin Optimisation report – first issue		June 2013
D4-2	Resin Optimisation and environmental testing report		June 2014
D5-1	Interface optimisation report – first issue		March 2014
D5-2	Interface optimisation and environmental testing report		Dec 2014
D6-1	Electrical machine manufacturing and defect investigation report		June 2015

4. Topic value (€)

200,000 €

Two hundred thousand Euro

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-SAGE-02-016	**Study and durability of electrical insulating material in aircraft engine chemical environment**	**Start date**	*Sept 2012*
		End date	*Dec 2015*

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

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

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

	2012		2013				2014				2015	
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
Task 1	■	■	■	■	■	■	■	■	■	■	■	■
Task 2 ●	■	■	■									
Task 3 ●		■	■									
Task 4 ●			■	■	■	■	■	■				
Task 5					■	■	■	■	■	■	■	■
Task 6 ●											■	■

Deliverable	Title	Description (if applicable)	Due date
D1-1	Monthly progress reports		Every month
D2-1	State of the art first report		March 2013
D3-1	Test plan and methodology – issue 1 : Material optimisation process method report		Dec 2012
D3-2	Test reports on material tests & analysis on test results and recommendations for task 4		March 2013
D4-1	Material sample initial state characterisation report and material sample for ageing study		June 2013
D4-2	Material interfaces sample initial state characterisation report and material sample for ageing study		June 2014
D5-1	Test results analysis & recommendations		June 2015

4. Topic value (€)

200,000 € Two hundred thousand Euro

Clean Sky Joint Undertaking
JTI-CS-2012-01-SAGE-02-017

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-SAGE-02-017	**Variable thickness lamination machine-tool design and manufacturing**	**Start date**	*Sept 2012*
		End date	*June 2014*

1. Topic Description

The SAGE2 Demonstration Project aims at designing, manufacturing & testing a Counter-Rotating Open-Rotor Demonstrator.
For one electrical system of the Open Rotor, specific rotating electrical machines have been designed to fit with the harsh environment and requirements of this system. To improve the performances of such electrical machines through an optimized design, variable thickness lamination is considered for the magnetic core (armature). Unfortunately such a lamination process appears to be not easily industriable at reasonable costs.
A machine-tool enabling a quick process for such a variable and precise lamination for Fe-Si armature (thickness varying typically from 0.2 to 0.24 mm on a heigth of 3 cm, meaning 10% every 15 mm) would then be a key enabler for industrial viability for this optimized design of the electrical machines for this system.
This topic is to design and manufacture such a machine-tool, and used it for manufacturing Fe-Si armature prototypes in the framework of this project.

NB: An adaptation of an existing machine-tool can also be considered.

The partner shall perfom the following activities :

Task 1: Project management
Planning and steering activities for the project
Quality management of the project

Task 2: Preliminary design of the machine-tool
Preliminary design of the variable thickness lamination machine-tool: assessment of the design with regards to the requirements, risk assessment

Task 3: Industrialisation potential assessment
Assessment of the potential of this machine-tool for industrialisation of armature production: estimation of the final cost and quality of armatures produced with such a machine-tool (analysing processing time, range of objects manufacturability with such a machine-tool, assessment of lifetime of the machine-tool)

Task 4: Detailed desing of the machine-tool
Detailed design of the variable thickness machine-tool
Justification of this design by detailed studies and simulations
Schedule for tool manufacturing / adaptation of an existing machine-tool

Task 5: Manufacturing of the machine-tool
Piloting the manufacturing of the machine-tool (suppliers, assembly)
Validate the good functioning of the machine-tool

Task 6: Manufacturing prototypes of Fe-Si armatures
Manufacturing prototypes of Fe-Si armatures for rotating electrical machine with this machine-tool and delivery to the project for integration in a demonstration

Task 7: Synthesis of the project
Analyse the performances reached and potential way of improvement in the design of machine-tool and in the process for manufacturing armature
Update the industrialization potential assessment

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

Lamination machine-tools design competencies
Machine-tool manufacturing and operating capability
Industrial engineering
Magnetic material (Fe-Si) experience

Capacity to carry out industrialization studies (technico-economical analysis) A consortium between companies and / or laboratories or institutes can answer to this project.

3. Major deliverables and schedule

	2012		2013				2014	
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
Task 1	■	■	■	■	■	■	■	■
Task 2	■	■						
Task 3	■	■						
Task 4			■	■				
Task 5					■	■		
Task 6							■	
Task 7								■

Deliverable	Title	Description (if applicable)	Due date
D1-1	Progress status		Every month
D2-1	Preliminary design of the machine-tool		Dec 2012
D3-1	Assessment of the potential of this machine-tool for industrialisation of armature production		Dec 2012
D4-1	Detailed design of the machine-tool		June 2013
D5-1	Manufacturing of the machine-tool		Dec 2013
D6-1	Manufacturing of armature prototypes and delivery to the project		March 2014
D7-1	Final report and industrialization opportunity assessment		June 2014

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.*

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-SAGE-02-018	**SAGE2 Engine Mounting System and Engine In-flight Balancing System**	**Start date**	T0
		End date	T0 + 36 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 topic is made of 2 parts:

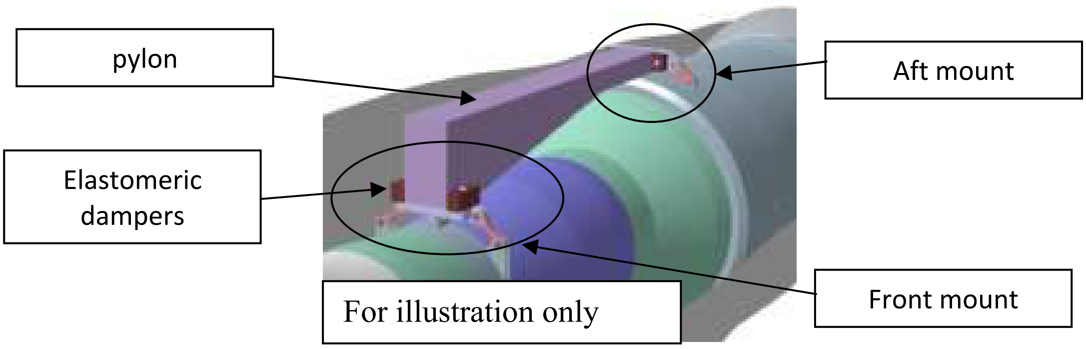
Part 1:

An Engine Mount System must be designed and manufactured so as to mount the engine on its pylon, also an Engine Inflight Balancing System must be designed and manufactured so as to implement automated balancer and assembly on rotor shafts or barrels

This Engine Mount System will be isostatic. In particular,

- The front mount will comprise a yoke, rods, ball joints that will be consistent will the donner engine interfaces.

- The aft mount will comprise a yoke, rods, and ball joints and a snout that will be consistent will the exhaust frame that will be designed by SNECMA



It must be noticed that, in order to dampen the vibration induced by the propellers, elastomeric devices will be introduced between the pylon and the Engine Mount System.

Part 2:

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 balde to balde pitch mismatch
- Fewer maintenance cost due to trim balancing
- Less vibration level in the Aircraft ➔ more confortable flight dot passengers and cabin crew

The Main issues to be adressed are :

- Balancing capability consistant with SNECMA 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
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

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 in Snecma facility.

General Requirements:

– The partner shall work to a certified standard process.

Work Package 1. Engine Mounts System

Task 1.1: mount system design

The partner shall design the mounts and elastomeric dampers, according to SNECMA and to the airframer's demonstrator flight-worthiness requirements in case this mounts concept would be selected for flight tests.

The partner shall deliver to Snecma the mount system data required for Whole Engine Model Analysis and for the Airframer's GFEM to be used for loads & Aero elastics loops

The partner shall deliver a design justification report of the mounts and elastomeric dampers

The partner shall support the technical review for mount system architecture approval organized by Snecma

Task 1.2: mount system component tests

The partner shall propose a mount system verification plan. This verification plan will be approved by Snecma 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 1.3: mount system delivery for ground test

The partner activities shall include:

- Manufacturing and/or procurement of the instrumented mounts and elastomeric dampers for engine assembly
- Conformity documents

Task 1.4: support to ground test (mounts)

The partner shall support Snecma during the ground tests:

- monitoring
- measures analysis
- Hardware changes if required by engine dynamic behavior

Work Package 2: Engine In Flight Balancing System

Task 2.1: Balancing system design:

- The partner shall design the engine in-flight balancing system according to SNECMA Requirements,
- The partner shall deliver to Snecma 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 Snecma.

Task 2.2: 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 Snecma 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

Task2.3: 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 2.4: support to ground test (Balancing system)

The partner shall support Snecma during the ground tests:

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

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

- Experience in design, manufacturing, testing and certification of aircrat engine mounts is mandatory
- 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	Mount and balancing systems development plan	Including detailed risk analysis and mitigation proposal and a preliminary test pyramid	T0 + 1 month
D2	Mount 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. Including Test pyramid, initial structural FEM model adapted for integration to global Aircraft FEM (GFEM) & preliminary local thermal model	T0+4 months
D3	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+4 months
D4	Design progress reports for mount and balancing systems	Design activities status	T0+10 months
D5	Mount system detailed design substantiation document for critical design review	To approve design before hardware manufacturing engagement. Including Test pyramid, structural FEM model adapted for integration to global Aircraft FEM (GFEM) & local thermal model	T0+16 months
D6	Balancing system detailed design substantiation document for Critical design review	To approve design before hardware manufacturing engagement	T0+16 months
D7	Mount and balancing systems Components Tests benches readiness review	To verify test benches capability to meet validation plan requirements	T0+18 months
D8	Mount and balancing systems Components Tests completed – hardware inspection review	To substantiate mount and balancing systems design	T0+26 months
D9	Balancing system hardware delivery	Engine assembly	T0+26 months
D10	Mount system hardware delivery	Engine assembly	T0+28 months
D11	Component Tests reports for mount and balancing systems	To contribute to engine test readiness review	T0+ 32 months
D12	Engine readiness review documentation: - Delivered Hardware status compared - Instrumentation - Test plan requirements	To contribute to engine test readiness review	T0+ 32 months
D13	Engine ground test report for mount & balancing systems	To contribute to engine after-test review	T0+ 36 months

4. Topic value (€)

3,000,000 €
Three millions Euro

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-SAGE-03-012	**Non-metallic Pipes for Aero engine Dressings**	**Start date**	July 2012
		End date	Jan 2014

1. Topic Description

SAGE3 project aims at development and demonstration of a large 3-shaft bypass engine Demonstrator. RTD activities are foreseen on developing non-metallic pipes and support system, to replace traditional metallic variants in engine externals. The objective of the work package is to develop this technology and demonstrate to Technology Readiness Level (TRL)6.

The operating temperature range capability of interest is -85°C to 165°C, but materials capable of operating in excess of this range are strongly preferred. The new non-metallic material must be Fire resistant to JES314-1 (which conforms to ISO2685) as a minimum and the system capable of continued operation in an engine 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 non-metallic pipework/supports

The Partner will conduct the mechanical concept and detail design of both pipework in a non-metallic material and of a suitable support system against supplied specification requirements (see below).

The Partner is expected to recommend new and novel end fittings. Whilst initial investigations into this technology have utilised current metallic fittings, the Partner is expected to recommend alternative fitting systems that optimise the overall piping solution.

The use of traditional P-clips and brackets adds weight and cost to an installation and so proposals for novel and integrated mounting systems optimised to the support of the non-metallic pipes are also expected.

The Partner will provide a detailed verification proposal for the new material/manufacturing process. The piping 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: Non-metallic pipework/supports manufacturing and assembly

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

It is also requested that the Partner suggests alternative pipe support systems for practical integration and assembly demonstration on an engine. This technology should replace traditional pipe clamps where possible and be suited for tube diameters of ¼” (6.35mm) to 1.5” (38.1mm.).

If it is agreed between the Partner and Topic Manager that a running engine test 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 whether this is envisaged, the number of pipes likely to be provided and the features requiring this validation.

Task 3: Non-metallic pipework/supports validation support

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

Non-metallic pipes and supports operating environment

	Min	Max
Environmental Temperature capability	-85°C	>165°C
Pipe outside diameter	0.25"	1.5"
Pipe bend radii	1.5 x OD	
Pipe length		1.8m
Pressure capability	-10psig	450psig working, 800psig max

New non-metallic material must be Fire resistant to JES314-1 (which conforms to ISO2685), as a minimum

Typical vibration 3 axes requirements:

0.030’’ pk-pk	**10-37Hz**
3.5’’/sec pk	**37-263Hz**
15g pk	**263-2000Hz**

Systems capability requirements:

- Expectation that non-metallic solution be used for all Aero engine Air and Oil pipework. Specifically drains, scavenge, sensor and vent lines
- Demonstrated resistance to Skydrol hydraulic fluid, oil and aviation fuel
- Material porosity should be as close as possible to zero
- The proposal must show how the Partner will address potential inter weave leaks at pipe bend radii
- The proposal should provide Partners suggestions on tube core material and design to enable complex 3D shapes to be created in a non-metallic material
- Partner should show in the proposal how the non-metallic solution will combat handling damage in service.

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

Extensive experience in the detail design, development, manufacture and validation of non-metallic materials. In-service operation of aerospace pipework would be an advantage. 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 applications would be an advantage. The Partner needs to be in the position to have access to the manufacturing facilities suitable for making an agreed subset of non-metallic pipes suitable for 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	Non-metallic pipes/support launch and concept review	Participate in launch review for SAGE3 non-metallic pipes/supports	July 2012
D2.1	Non-metallic pipes/support Prelim Design Review		Sept 2012
D2.2	Non-metallic pipes/support Critical Design Review		Dec 2012
D3.1	Launch manufacture of tech demo hardware for validation testing		Jan 2013
D3.2	Deliver validation hardware		May 2013
D3.2	Validation testing		During 2013
D4.1	End of validation testing report issued		Dec 2013

4. Topic value (€)

1,800,000 € **[one point eight 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. 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 – key programme, technology, material, manufacturing and budget risks.
3. Detailed design and make plan with decision gates and contingency loops. The plan must include a clear material and feature selection process.
4. The proposal must include details of material supplier agreements. Lead times for material delivery, quantities, costs, contingencies, etc. should be indicated.
5. Verification of successful manufacture. Requirement to demonstrate in proposal how the Partner would ensure a non-metallic tube is acceptable for useage within the engine conditions listed. I.e. inspection techniques. Sub-laminar inspection, ultrasonic, X-ray inspections, etc.
6. Partner to demonstrate preparation method and successful use of adhesives for end fitting application
7. Partner to suggest how the manufacturing process could be automated

Clean Sky Joint Undertaking
JTI-CS-2012-01-SAGE-03-013

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-SAGE-03-013	**Extended operation temperature range for compressor structure materials**	**Start date**	*T0*
		End date	T0+30M

1. Topic Description

Significant reductions in specific fuel consumption, nitrous oxide emissions and noise of large turbofan engines will require developments in lightweight and efficient components and possible changes to the thermodynamic cycle compared with current state of the art engines. Building on technologies developed in existing programmes (including VITAL and NEWAC), the SAGE 3 project will demonstrate a number of technologies applicable for large 3-shaft turbofan engines that will reduce weight and improve efficiency. In order to answer the needs of the SAGE3 project in terms of research, technological development and demonstration activities, it is planned to offer individual tasks to the industry, RTOs, universities or any legal entity. Therefore, the present Call for Proposal supports further exploration and development of titanium alloys for higher temperature capability to enable higher overall pressure ratios in aero-engines with maintained low weight components.

The trend for new core compressor structures is an increasing pressure, and with increasing pressure the temperature in the compressor also increases. Because of their high specific strength (strength-to-weight-ratio), titanium alloys have been the most advantageous material group selected for design and manufacturing of compressor parts and structures that are exposed to temperatures not exceeding ~450°C. Up to this temperature the alloy Ti-6Al-2Sn-4Zr-2Mo is typically used, but if this alloy is exposed to even higher temperatures, up to 500°C or even higher, which is the trend in future engines as mentioned before, this titanium alloy may need to be replaced by some other titanium alloy or nickel base alloy that can withstand the higher temperatures in the compressor. Titanium alloys are still believed to be the best choice for minimizing the weight of the intermediate compressor casing (ICC), therefore one of the main objectives of this WP is to explore and find another potential titanium alloy(s) that can replace the currently used Ti-6Al-2Sn-4Zr-2Mo, for long time use at temperatures 50°C higher then Ti-6Al-2Sn-4Zr-2Mo in structure applications. In addition, at temperatures exceeding approximately 480°C oxidation and formation of brittle alpha case in titanium alloys becomes a serious issue, which can be detrimental to the life of a component and therefore also needs to be addressed in the present work.

Because of the large size of the ICC, one piece castings are expensive and difficult to manufacture. Instead, fabrication of large intermediate casings, through assembly of sub-components by welding, has proven to be a competitive way of manufacture these large components. Figure 1 shows an example of a fabricated ICC manufactured by welding together castings, sheet and wrought sub-components. The fabrication concept makes it possible to optimize the design, both in terms of minimizing weight and optimizing the mechanical properties, by allowing the selection of the optimised form of the selected alloy for a particular area of the ICC. Therefore another important aspect of the materials selected for manufacturing of future intermediate compressor casings is that they should be available in different forms, i.e. wrought products and castings. Yet another form available is Hot Isostatically Pressed (HIP) powder of the material. HIP:ing is a near net shape process that has the potential to

directly manufacture finished products by compressing and sinter powder. The mechanical properties of such form of material are usually as good as or even better than cast material. The drawback of this form of material today is the high manufacturing cost of the powder used in this process. However, recent developments in the production of titanium powder indicate that in a near future significantly cheaper titanium powder of both pure Ti and titanium alloys could be available. When this happens the manufacturing of HIP:ed titanium alloy parts and components can become a significant cost saver. Therefore, some limited work on evaluating the mechanical properties of HIP:ed form of the selected material should also be considered within the framework of this WP.

Figure 1. *This picture shows an example of a fabricated Intermediate Compressor Casing (ICC), which consist of castings, forgings and sheet.*

Based on the requirements now mentioned for the intermediate compressor casing, the criteria for future ICC materials can be summarized as follows:

- Titanium alloy(s) for long term use at temperatures 50°C higher than Ti-6Al-2Sn-4Zr-2Mo.
- Titanium alloy(s) need to be available in cast and wrought form, and weldable.
- Alpha case build with time and temperature – its effect on mechanical properties?
- What are the mechanical properties (cast, wrought, welded, powder+HIP)?
- Cost?

<u>Task 1: Management</u>

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.

General Requirements:

– The partner shall work to a certified standard process.

<u>Task 2: Literature review and survey of currently existing commercially available titanium alloy(s) used at temperatures up to Ti-6Al-2Sn-4Zr-2Mo +50°C</u>

The immediate first part of this work should include a comprehensive survey of what titanium alloys that are commercially available today and that could be used 50°C higher then Ti-6Al-2Sn-4Zr-2Mo for longer times. This survey would preferably consist of a literature study and review of published work in international journals and conferences. This review work will then function as the background for selecting the most promising titanium alloy(s) to manufacture and perform mechanical testing on, explained more in Task 3 below. A draft of this report shall be sent to the Topic Manager for approval, before finalised.

Task 3: Manufacture of representative but simplified parts of the most promising titanium alloy(s)

From the review work in Task 2 it will be possible to distinguish one or two titanium alloys that have greatest potential in fulfilling the requirements of this WP. In Task 3 the most promising titanium alloy(s) is/are selected and manufactured in at least three of the following forms:

- Investment casting of part;
- Ring rolled part;
- Welded part;
- Hot Isostatic Pressing of powder of selected titanium alloy(s);

In addition, it is also important investigate the availability of the selected titanium alloy(s) in sheet as well as in welding wire. A feasibility test for welding the selected alloy to **Ti-6Al-2Sn-4Zr-2Mo** should also be included.

Task 4: Evaluation of microstructure and properties of selected titanium alloy(s)

A test plan for the mechanical testing should here be presented and sent to Volvo Aero Corporation for approval before commencing with manufacture of test specimens and the mechanical testing. The mechanical properties that need to be investigated are:

- Tensile properties;
- Creep resistance;
- Fatigue life;
- Microstructure examination and documentation of all different materials that are mechanically tested should also be included.

In addition to these properties it is also important to perform some kind of evaluation of alpha case growth kinetics at the elevated temperature(s) on the investigated titanium alloy(s). Alpha case is an oxygen-enriched brittle layer that forms in the surface region of titanium alloys when exposed to temperatures exceeding ~480°C in air. It is known to have a detrimental effect on especially the fatigue strength. If alpha case growth is found significant in the current tests this needs to be handled within the mechanical test plan as well, to evaluate and document the effect of alpha case on the mechanical properties.

Task 5: Report

The final report should include the literature survey of potential titanium alloys for use at temperatures 50°C higher then Ti-6Al-2Sn-4Zr-2Mo, in which it is clearly concluded which titanium alloy(s) seems most promising in fulfilling the aim and requirements of this WP. The report shall also include full documentation of the different forms of titanium alloy materials, and all results from the mechanical testing should be presented in tables and diagrams according to conventional practice. Remaining test material shall be submitted to the Topic Material as is requested.

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

- The CfP partner should have equipment, or an available supply network for investment casting of titanium alloy components.
- The CfP partner should have equipment, or an available supply network, for manufacturing of ring rolled titanium alloy parts.
- The CfP partner should have equipment, or an available supply network, for manufacturing of Hot Isostatic Pressing (HIP) of titanium alloy powder into near net shape parts.
- The CfP partner needs testing and analysis equipment for evaluating the mechanical properties of different forms of titanium alloys, or an available supply network that can perform these trials. This includes e.g.

metallography and mechanical testing according to aerospace standards.

- Experience in performing applied collaborative industrial research in international environment is considered as essential.

3. Major deliverables and schedule 30 Months

Deliverable	Title	Description (if applicable)	Due date
D1	Detailed Project Plan.	Task 1: Schedule with milestones.	T0 + 1M
D2	Literature survey of potential titanium alloys for long term use at temperatures 50°C higher then Ti-6Al-2Sn-4Zr-2Mo.	Task 2: This survey should indicate at least one potential titanium alloy that could function as a future ICC material, and suggest the titanium alloy(s) to be further investigated in this project.	T0 + 3M
D3	Plan for manufacturing of one or two potential titanium alloy(s) in different conditions (cast, wrought, welded).	Task 3: This delivery is a plan that consists of two parts: 1) The first part briefly explains the background for selecting the particular titanium alloy(s) mainly by referring to the conducted literature survey. 2) The second part explains the decision of material conditions to be evaluated (cast, wrought, welds and/or HIP+powder) and the geometry/type of part to manufacture with the different processes. The selection of one or two titanium alloys as well as the geometry of parts to be manufactured should be decided in close dialogue with the Topic Manager.	T0 + 4M
D4	Test plan for mechanical testing and microstructural characterization.	Task 4: This delivery is a complete test plan for the mechanical testing. This delivery, in the form of a report, shall be subject for approval by the Topic Manager before start of work.	T0 + 5M
D5	Documentation of results from manufacturing of the different conditions of the titanium alloy(s).	Task 3: All documentations that are related to the manufacturing of the different material conditions and parts should be collected and synthesized into a report. This report shall be subject for approval by the Topic Manager.	T0 + 20M
D6	Results from mechanical testing and microstructural characterization of the investigated titanium alloy(s).	Task 4: This report contains all test results from the mechanical testing and also the microstructural characterization of all investigated material conditions. This report shall be subject for approval by the Topic Manager.	T0+28M
D7	Final report containing all results and findings within this WP.	Task 5.	T0 + 30M

4. Topic value (€)

800,000 €
Eight 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

All documents are preferably written in English.

Topic Description

CfP topic number	Title		
JTI-CS-2012-01-SAGE-05-016	**Telemetric System Acquisition in harsh Environment**	**Start date**	01/03/2012
		End date	*(24 month)*

1. Topic Description

SAGE 5 project aims at developing new innovative technologies that meets the ACARE targets in term of fuel consumption, noise and greenhouse gas emissions reduction. In order to optimize the development of each part of the turbo engine, TURBOMECA needs to measure parameters on rotating assemblies.

The aim of this project is to develop and manufacture a wireless system of data transmission suited for harsh environment.

The harsh environment is characterized by

- high temperature environment (up to 150°)
- high rotating speed of the rotor (up to 45.000 RPM)
- low dimension

The Telemetric System includes electronic system and adaptation part that suits engine parts.

Specific requirements:

The system developed shall fulfil the requirements specified by TURBOMECA.

Installation:

- The system will be installed in the casing of the Power Turbine
- Dimensions allowed for:

Static components: included in cylinder height 40 mm, inner diameter 40 mm, outer diameter 80mm

Rotating components: included in cylinder height 45 mm, inner diameter 40mm / outer diameter 55mm

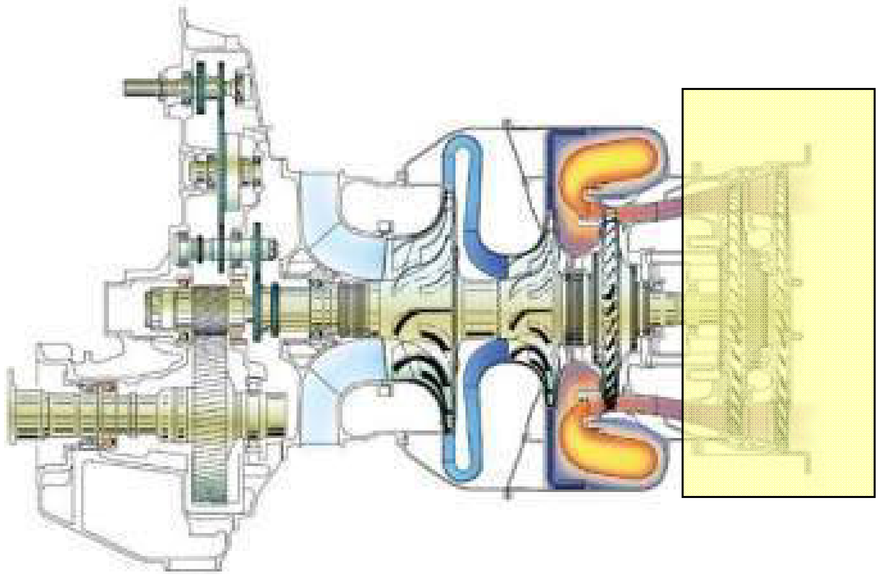


Figure 8 : Settlement area of telemetric system

Conditioning:

- The system must be able to condition two types of sensor up to 15 measurement channels
- Main characteristic
  - High frequency bandwidth (20 kHz)
  - Low level signal to noise ratio (80 dB)
- Suitable for :
  - Type 1: Strain gage (Quarter Bridge, 120 Ω and 350 Ω)
  - Type 2 : Thermocouple (K type)

Transmission:

- High frequency bandwidth (allowing transmissions of 15 measurements channels data)
- Output data must be available on numerical and analogical form

Mechanical :

- The telemetric system must be studied and fitted to engine part, but if any modification could concern mechanical part of the engine. Turbomeca will have to verify the integrity and the mechanical behaviour of the proposed modification.

Task 1: Management

Organisation:

– The partner shall nominate a team dedicated to the project and should inform TURBOMECA project 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 TM)
- Inform Turbomeca of any deviation …

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 work packages, 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 in TURBOMECA.

Task 2 : Preliminary Telemetric System design

- The partner will make a state-of-the-art of the different technologies of wireless data transmission suited for harsh environment up to 150°.

- The partner will analyse the different solutions in order to choose the most accurate telemetric technology compatible with demonstrator environment.

Task 3 : Detailed of Telemetric Sytem design

- The Partner will provide a detailed design of the telemetric system based on the requirements provided on task 2.

- The Partner will provide a detailed design of the adaptation parts to be fitted on turboshaft-engine in order to install the telemetric device.

Task 4 : Telemetric System Manufacture and Test

- The Partner will procure all materials and fittings and manufacture all components to provide a prototype of the telemetric system as defined in task 3.
- The Partner will define a validation test plan
- The Partner will perform laboratory (bench) validation tests in order to demonstrate the capability of the design to fulfil requirements an also its performance and durability.
- The Partner will provide a test result report

Task 5: Telemetric System Validation on Engine

- The Partner will deliver the telemetric system to TURBOMECA for testing on the turboshaft engine demonstrator
- The Partner will attend the engine test in order to assist TURBOMECA in the adjustment of the telemetric system.
- The Partner will provide a test report with the telemetric system performance, possible improvements.

It should be noted that the partner should expect that the validation tasks 4 & 5 will consume a large percentage of the award.

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

-The partner must have experience in the design, fabrication, and testing of aerospace measurement systems.

- In case of response by a several partners, at least one of the partners (coordinator) must exhibit experience in the management of a consortium.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Detailed project plan	Schedule with milestones	T0+1M
D2	Preliminary Telemetric System Design	Present one or more potential system concepts for review and approval.	T0+4M
D3	Detailed of telemetric system design	Report to contain detailed drawings, predicted capability, and results of any analysis performed during the design process. Go/No Go review	T0+10M
D4	Telemetric System Manufacture and Test	Prototype of Telemetric System. Results of bench testing and verification that the prototype system is in accordance with Requirements Go/No Go review	T0+16M
D5	Telemetric System Validation on Engine	Telemetric System and adaptation parts for turbo engine. Results of gas turbine engine test and verification that the prototype system is in accordance with requirements	T0+20M
D6	Engine Test Report	Report providing an overview of: - Telemetric System performance - Recommendations to support TRL progression -Recommended changes for next iteration	T0+24M

4. Topic value (€)

400,000 € Four hundred thousand Euro