Clean Sky Joint Undertaking
Call SP1-JTI-CS-2010-04

European Commission
Research Directorates

Call for Proposals:

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

Call Text

Call Identifier
SP1-JTI-CS-2010-04

Index

Document track changes

Page/topic	Original	Correction or modification

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- Topic manager (not to be published)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)					Total receipts	Requested JU contribution
			RTD	Demonstration	Management	Other	TOTAL		
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.

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: 27 July 2010**
- **Call close: 12 October 2010, 17:00**

- Evaluations (indicative): 8-12 November 2010

- Start of negotiations (indicative): 01 January 2011
- Final date for signature of GA by Partner: 15 February 2011
- Final date for signature of GA by Clean Sky JU: 28 February 2011

Recommendation

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:

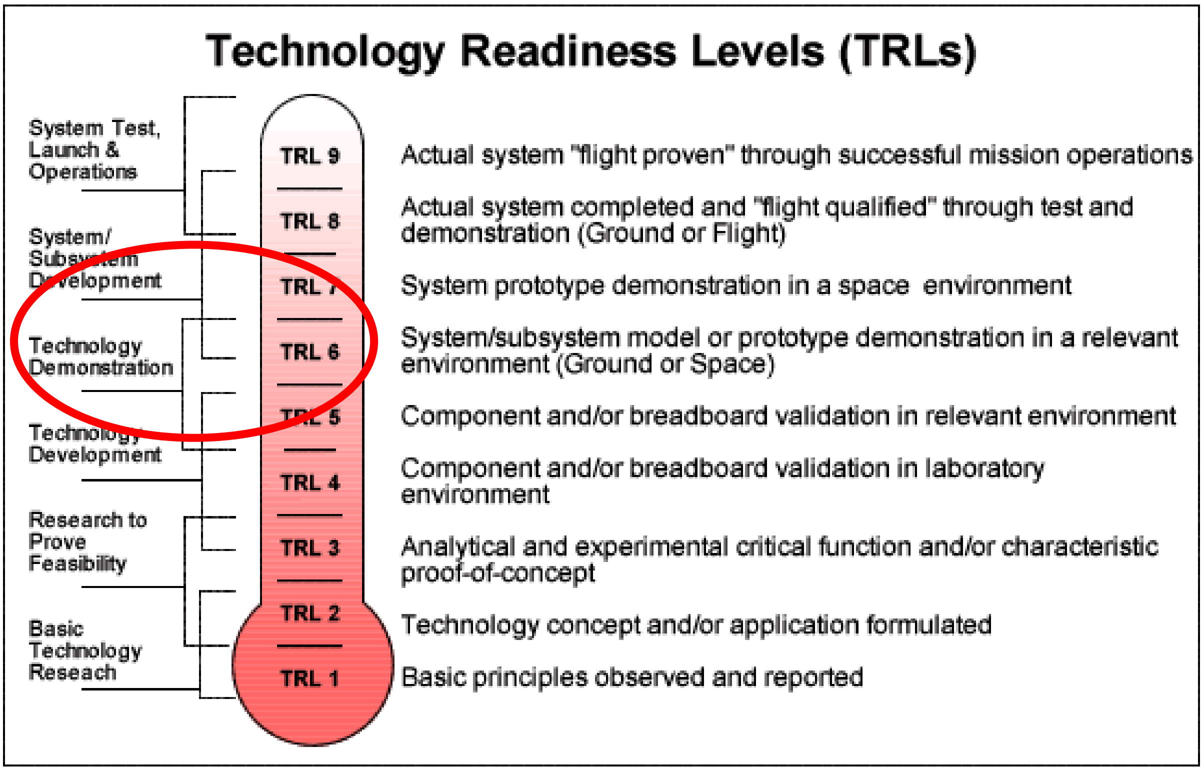
info-call-2010-04@cleansky.eu

Questions received until **17 September 2010** will be considered.

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).

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

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:



The Topics proposed by the ITDs are listed in the next table.

Identification	ITD - AREA - TOPIC	topics	VALUE	MAX FUND
JTI-CS-ECO	**Clean Sky - EcoDesign**	3	2,200,000	1,650,000
JTI-CS-ECO-01	*Area-01 - EDA (Eco-Design for Airframe)*		**500,000**	
JTI-CS-2010-4-ECO-01-008	Development of thermoplastic polymer blend with low melting point and properties close to PEEK ones		200,000	
JTI-CS-2010-4-ECO-01-009	Moisture aging of composites - Time-Temperature - Moisture superposition principle - Hydric fatigue		300,000	
JTI-CS-ECO-02	*Area-02 - EDS (Eco-Design for Systems)*		**1,700,000**	
JTI-CS-2010-4-ECO-02-005	Development, Construction and Integration of Systems for Ground Thermal Test Bench		1,700,000	
JTI-CS-GRA	**Clean Sky - Green Regional Aircraft**	4	2,650,000	1,987,500
JTI-CS-GRA-01	*Area-01 - Low weight configurations*			
JTI-CS-GRA-02	*Area-02 - Low noise configurations*		**150,000**	
JTI-CS-2010-4-GRA-02-013	Novel nose wheel evolution for noise reduction		150,000	
JTI-CS-GRA-03	*Area-03 - All electric aircraft*		**500,000**	
JTI-CS-2010-4-GRA-03-002	Energy Management – Electrical motors power control. Analytical studies and modeling		350,000	
JTI-CS-2010-4-GRA-03-003	Development of Numerical Models of Aircraft Systems to be used within the JTI/GRA Shared Simulation Environment		150,000	
JTI-CS-GRA-04	*Area-04 - Mission and trajectory Management*			
JTI-CS-GRA-05	*Area-05 - New configurations*		**2,000,000**	
JTI-CS-2010-4-GRA-05-005	Aero-acoustic noise emissions measure for advanced Regional Open Rotor A/C configuration.		2,000,000	
JTI-CS-GRC	**Clean Sky - Green Rotorcraft**	3	1,165,000	873,750
JTI-CS-GRC-01	*Area-01 - Innovative Rotor Blades*		**575,000**	
JTI-CS-2010-4-GRC-01-005	Gurney flap actuator and mechanism for a full scale helicopter rotor blade		575,000	
JTI-CS-GRC-02	*Area-02 - Reduced Drag of rotorcraft*		**590,000**	
JTI-CS-2010-4-GRC-02-003	Contribution to optimisation of heavy helicopter engine installation design		440,000	
JTI-CS-2010-4-GRC-02-006	Helicopter hub and fuselage drag investigation by means of hybrid URANS/LES methods		150,000	
JTI-CS-GRC-03	*Area-03 - Integration of innovative electrical systems*			
JTI-CS-GRC-04	*Area-04 - Installation of diesel engines on light helicopters*			
JTI-CS-GRC-05	*Area-05 - Environmentally friendly flight paths*			
JTI-CS-SAGE	**Clean Sky - Sustainable and Green Engines**	10	7,950,000	5,962,500
JTI-CS-SAGE-01	*Area-01 - Geared Open Rotor*			
JTI-CS-SAGE-02	*Area-02 - Direct Drive Open Rotor*			
JTI-CS-SAGE-03	*Area-03 - Large 3-shaft turbofan*		**3,800,000**	
JTI-CS-2010-4-SAGE-03-003	High Efficiency Fuel Pumping		1,500,000	
JTI-CS-2010-4-SAGE-03-004	Fuel Control System Sensors and Effectors		1,300,000	
JTI-CS-2010-4-SAGE-03-005	High Temperature Electronics		1,500,000	
JTI-CS-2010-4-SAGE-03-006	Ring Rolling of IN718		1,000,000	
JTI-CS-SAGE-04	*Area-04 - Geared Turbofan*		**4,150,000**	
JTI-CS-2010-4-SAGE-04-001	Development of low cost near conventional hot die forging process for gamma-TiAl low pressure turbine blades		650,000	
JTI-CS-2010-4-SAGE-04-002	Development of near net shape isothermal forging process for gamma-TiAl low pressure turbine blades		600,000	
JTI-CS-2010-4-SAGE-04-003	Development and validation of an integrated methodology to establish future production concepts		1,000,000	
JTI-CS-2010-4-SAGE-04-004	Development of low cost casting process for gamma - TiAl billets		550,000	
JTI-CS-2010-4-SAGE-04-005	Development & Manufacture of High Temperature Carbon Fibre Reinforced Plastic (CFRP) Aero engine Parts for Continuous Use at Temperatures above 350°C		850,000	
JTI-CS-2010-4-SAGE-04-006	Machining of highly stressed components: Development of Precise Electrochemical Machining (PECM) Simulation		500,000	
JTI-CS-SAGE-05	*Area-05 - Turboshaft*			
JTI-CS-SFWA	**Clean Sky - Smart Fixed Wing Aircraft**	5	2,105,000	1,578,750
JTI-CS-SFWA-01	*Area01 – Smart Wing Technology*		**1,455,000**	
JTI-CS-2010-4-SFWA-01-013	Active Flow Control (AFC) techniques on trailing edge shroud for improved high lift configurations - design,		460,000	
JTI-CS-2010-4-SFWA-01-028	Structural tests on smart droop nose device with regards to aircraft level		745,000	
JTI-CS-2010-4-SFWA-01-029	Development, design and manufacture and test of AFC actuator controller wrt industrial purposes and		250,000	
JTI-CS-SFWA-02	*Area02 – New Configuration*		**650,000**	
JTI-CS-2010-4-SFWA-02-010	Innovative shield design and manufacturing		250,000	
JTI-CS-2010-4-SFWA-02-011	Impact test campaign		400,000	
JTI-CS-SFWA-03	*Area03 – Flight Demonstrators*			
JTI-CS-SGO	**Clean Sky - Systems for Green Operations**	4	2,750,000	2,062,500
JTI-CS-SGO-01	*Area-01 - Definition of Aircraft Solutions and explotation strategies*			
JTI-CS-SGO-02	*Area-02 - Management of Aircraft Energy*		**2,250,000**	
JTI-CS-2010-4-SGO-02-014	Construction of evaluation Power Modules (10) to a given design		250,000	
JTI-CS-2010-4-SGO-02-030	Test rig for endurance and reliabilty trials applied on TRL growth of high power Starter / Generators		2,000,000	
JTI-CS-SGO-03	*Area-03 - Management of Trajectory and Mission*		**500,000**	
JTI-CS-2010-4-SGO-03-009	Propfan equipped aircraft noise model		350,000	
JTI-CS-2010-4-SGO-03-010	High speed numerical integration techniques for precise prediction		150,000	
JTI-CS-SGO-04	*Area-04 - Aircraft Demonstrators*			
JTI-CS-SGO-05	*Area-05 - Aircraft-level assessment and exploitation*			
JTI-CS-TEV	**Clean Sky - Technology Evaluator**	0		
		topics	VALUE	FUND
	totals (€)	29	18,820,000	14,115,000

Clean Sky – EcoDesign

Identification	ITD - AREA - TOPIC	topics	VALUE	MAX FUND
JTI-CS-ECO	**Clean Sky - EcoDesign**	**3**	**2.200.000**	**1.650.000**
JTI-CS-ECO-01	*Area-01 - EDA (Eco-Design for Airframe)*		**500.000**	
JTI-CS-2010-4-ECO-01-008	Development of thermoplastic polymer blend with low melting point and properties close to PEEK ones		200.000	
JTI-CS-2010-4-ECO-01-009	Moisture aging of composites - Time-Temperature - Moisture superposition principle - Hydric fatigue		300.000	
JTI-CS-ECO-02	*Area-02 - EDS (Eco-Design for Systems)*		**1.700.000**	
JTI-CS-2010-4-ECO-02-005	Development, Construction and Integration of Systems for Ground Thermal Test Bench		1.700.000	

Clean Sky Joint Undertaking
JTI-CS-2010-4-ECO-01-008

Topic Description

CfP Nbr	Title		
JTI-CS-2010-4-ECO-01-008	**Development of thermoplastic polymer blend with low melting point and with similar properties to PEEK**	**End date**	To+10M
		Start date	To

1. Topic Description

Introduction

Today, carbon fiber reinforced composites with thermoplastic matrix are developed for aircraft structural applications. These thermoplastic composites have a lot of benefits, they have an unlimited life time at room temperature, they can be recycled and they have a better impact resistance than thermoset composites. For aeronautic applications, the main thermoplastic engineering polymer used is the PEEK. This polymer offers very interesting properties:

- High temperature resistance
- Excellent resistance to a wide range of organic and inorganic chemicals
- Excellent mechanical properties at high temperature and in rigorous environment
- Good fire resistance.

But, PEEK has a very high melting point (343°C) and as a consequence a very high processing temperature (around 400°C) that requires a lot of energy for processing and the use of costly environment products.
New eco-friendly thermoplastic materials able to be manufactured with less energy than PEEK or with alternative energy sources have to be investigated.

Objectives

The objective of this call for proposal is to develop a thermoplastic matrix with a lower processing temperature than PEEK for composite applications in aeronautics. The mechanical and physico-chemical properties of this thermoplastic blend have to be similar to the PEEK properties.
The development of this material will enable to reduce the global energy to transform and consolidate thermoplastic composite parts and also to avoid the use of costly environment products such as specific vacuum bags.

Requirements

The development of the thermoplastic material will be focused on the investigation of thermoplastic blends. The polymer selection for the blend must be focused on thermoplastic engineering polymers. The blend can be made from semi-cristalline or amorphous polymers.
The polymer blend shall have a processing temperature under 300°C and a glass transition higher than 140°C. The viscosity at the molten state must be as low as possible to enable the processing of this blend like impregnation of carbon fabric by a hot press processing.
The mechanical and physico-chemical properties of the thermoplastic blend should be similar to PEEK properties. The reference for the mechanical properties of the blend is the unfilled PEEK grade 150 from Victrex (see the datasheet "VICTREX® PEEK™ 150G / 151G" available on Victrex website). Deviations up to 25% of these mechanical properties are acceptable for the developed material.
The blend shall have properties suitable for aeronautic applications: resistance to solvent (fuel, hydraulic fluid, MEK…), resistance to fire (Fire/Smoke/Toxicity specifications), resistance at high temperature, moisture regain…
The blend should be preferentially mixed mechanically in the molten state thanks to an extruder to avoid if possible a solvent solution blending. The miscibility of polymers can be improved with a compatibilizer which can be reactive during the extrusion process.
The developed thermoplastic blend with the required properties shall be delivered under the form of films (thickness < 100µm). The physico-chemical properties such as the thermal properties

mechanical (processing temperature, glass transition, crystallinity, viscosity, processing…) and the mechanical properties will be characterized to validate the blend.

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

The applicant must have knowledge on thermoplastic polymer blends and must have facilities to manufacture polymer blends and to deliver it in the form of films (or pellets).

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Feasibility study and selection of polymers report		To+4M
D2	Delivery of polymer blend with required properties under film or pellet form		To+10M

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

The specified properties for the development of the polymer blend can be slightly extended (processing temperature, glass transition, and mechanical properties…) if none of the response fulfills all the requirements.

Topic Description

CfP topic number	Title		
JTI-CS-2010-4-ECO-01-009	**Moisture ageing of composites –Time-Temperature - Moisture superposition principle – hydric fatigue**	End date	*To+36*
		Start date	*To (01/07/2010)*

1. Topic Description

The employment of Carbon Fibres Reinforced Polymer (CFRP) composite material is increasing for aircraft and helicopters for "hot" and "wet" structural parts. In such applications composite materials are subjected to severe and coupling mechanical solicitations, hydric fatigue, besides mechanical loading. Accelerated Testing Method (ATM) is a way of rapidly generating long-term durability database with accelerated testing conducted at elevated temperature and moisture. The Time-Temperature Superposition Principle (TTSP) equivalency has been well-established founding for non-destructive properties, such as creep compliance and storage modulus of many viscoelastic materials from relatively short-term tests at several elevated temperatures. Since Miyano's pioneering work, there have been many successful attempts to extend TTSP to destructive properties such as static, creep and fatigue strengths. The ATM has been developed based on experimental observation that the composite plies and laminates follow the time and temperature dependencies of the viscoelastic matrix material. The strength of the viscoelastic material subject to loadings at various temperature and moisture and rates of loading could be measured and formulated as a function of the temperature, moisture and time-to-failure.

Using the TTSP, modulus and strength data, measured at several elevated temperatures for short-term loading could be shifted to long-term loading range at a reference temperature, and thus superposed to form the master curves of modulus and strength at the reference temperature and moisture, respectively. By using the master curves, the time and the temperature/moisture could be interchangeable; meaning acceleration in time could be achieved by raising temperature and moisture. Once the master curves are generated with the accelerated testing, they could be used to obtain the long term modulus and strength data under various loading and environmental conditions, such as stress/moisture levels with fatigue loading, as the mastercurves, the life prediction as well as residual strength prediction could be possible under arbitrary stress/moisture on fatigue loading. Compared to other existing methods, the ATM is a very versatile method that could handle a wide spectrum of loadings and environmental conditions. Furthermore, based on crack kinetics of the viscoelastic material, the mastercurves could be formulated with a few fit constants, taking probabilistic aspects into account of the scatter of the data.

However, based on existing experience, this approach seems rather adequate (if not limited) for exposure to constant environmental conditions. Past experience of the Topic defining company has shown that local damage patterns may be influenced by variable environmental conditions with respect to constant conditions. Therefore, it is expected that the applicant will select, propose and develop an approach, either based on ATM if feasible or on local damage analysis, to explain the difference between constant/variable exposure conditions.

Therefore, the two major objectives of the applicant are 1) to validate the applicability of ATM to strength on one or two aeronautical materials, 2) to validate a method accounting for discrepancies in damage patterns between constant and variables environmental exposure.

The work will be carried out on one aeronautical material of interest. The testing for validation will cover both static tests (with a maximum of three simple material coupons, with or without holes) and fatigue tests (for one material coupon). The full test definition is part of the study, however a typical test workload should be about 3 to 6 specimens per configuration, with varying environmental exposures (3 temperatures, 3 moisture conditions, exposures for a day to a month or so). The validation should be extended to the structural detail level, only for one configuration and 3 exposure conditions maximum. The definition of the adequate specimen for demonstration is part of the work of the applicant, in coordination with the Topic defining company. However the complexity expected is typically a small bolted assembly or notched coupon with possibly very simple stiffeners/over-thicknesses.

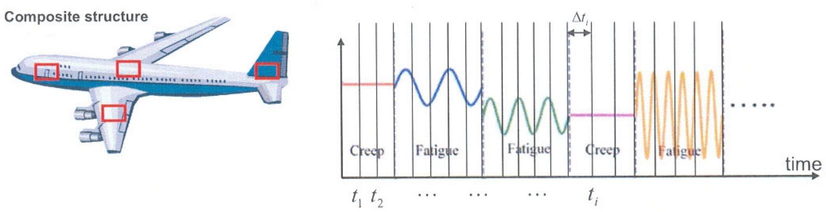


Figure 1: Calculate time-to-failure of composite structure submitted to cyclic hydric/mechanical loadings

So, for the development of new method to predict time-to-failure of composite structure particularly on wet ageing thematic, the following specific tasks are requested:

- TTSP application to effects of hydric aging on failure stress of composite material.
- Accelerated aging conditioning for thick/thin composite laminate to evaluate the damage due to cyclic hygrothermal conditions.
- Selection of a composite structure demonstrator (natural ageing, accelerated ageing, test to failure)
- Implementation of a tool for long term duration and to calculate time to failure of the selected composite part (temperature/moisture). For material analysis, a stand-alone software (in Fortran or C) is acceptable, however for structural detail analysis, the software tool should be either coupled or integrated in a finite element solver (see below). The verification of the software should be strictly limited to fit into the top level objective (method validation at research level), not going for a production tool.

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

The applicants should have test facilities to apply and to observe damage caused by cyclic hydric loading relevant to thick cyclic composite laminates. They should also have capacities to implement user laws in the Finite Element Software SAMCEF.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Annual report (State of the art, Bibliography, specimen definition, test program)	Report	T0 + 12M
D2	Mid report (Model, tests data, damage characterization, selection of composite structure demonstrator)	Report	T0 + 24M
D3	Final report (Synthesis report Conclusion and Perspectives)	Report	T0 + 36M
D4	Tests data. Samcef Routine users		T0 + 36M

4. Topic value (€)

The total value of this work package shall not exceed:

€ 300,000.—
[three hundred thousand euro]

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

5. Remarks

If applicable

Topic Description

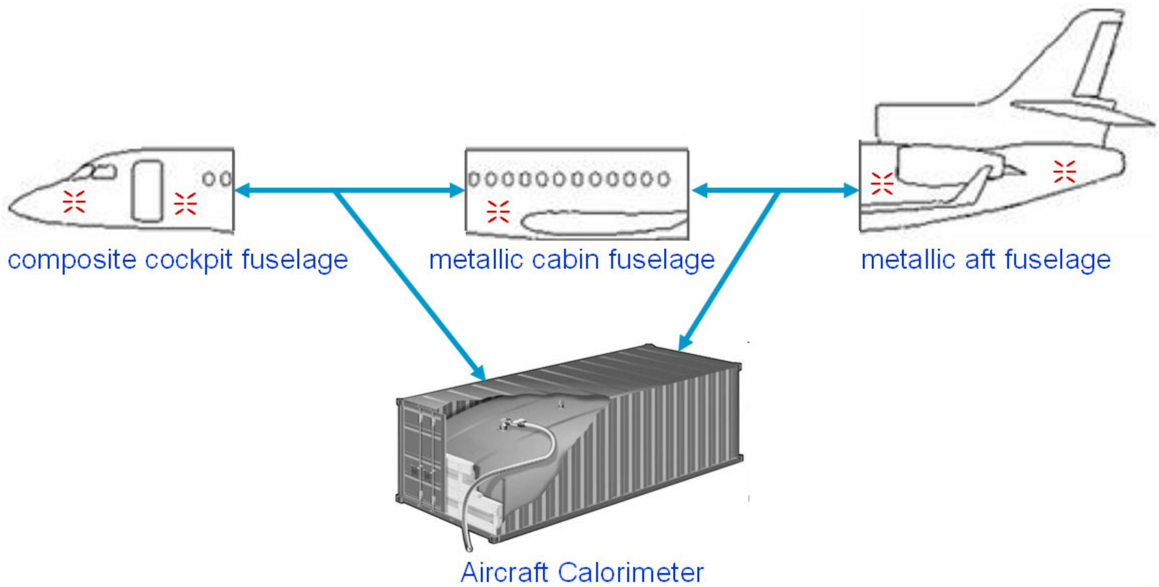
CfP topic number	Title		
JTI-CS-2010-4-ECO-02-005	**Development, Construction and Integration of Systems for Ground Thermal Test Bench**	**End date**	*T0+24M*
		Start date	*T0*

6. Topic Description

Introduction

The general objective of this part of the Eco-Design ITD is to make a significant step towards the concept of the all-electric vehicle systems aircraft. Thus the feasibility of such an aircraft has to be investigated through the study of innovative energy management architectures while reducing ground and flight tests with innovative concepts and technologies.

To develop, validate and finally demonstrate these energy management architectures a ground thermal test bench will be installed based on the use of an aircraft representative fuselage including various typical areas to cover the problems encountered for the thermal modelling. To achieve this the ground thermal test bench is planned to consist of three fuselage mock-ups containing operable systems and an ancillary thermal bench element with modular measurement and calibration capability in form of generic environmental chamber(s) (hereafter Aircraft Calorimeter – ACC) able to cycle further small aircraft components:



Objective

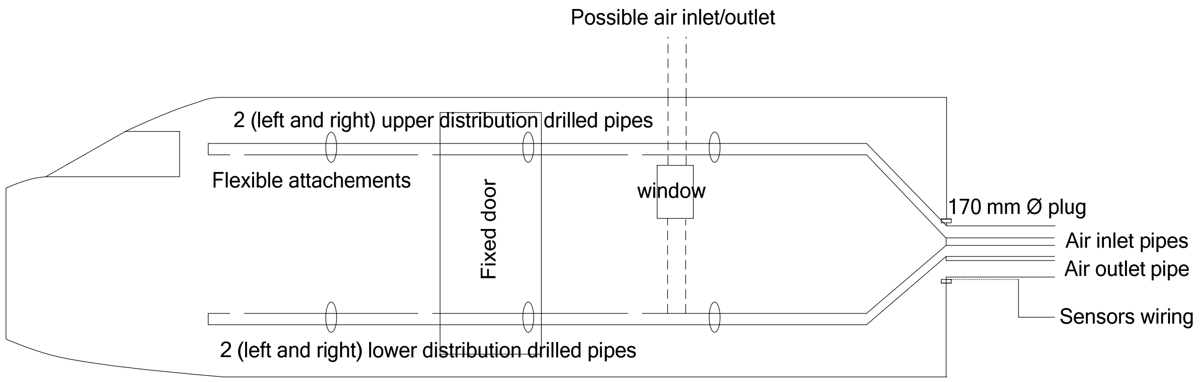
Using already existing infrastructure to condition aircraft environmental systems this call for proposal addresses the development, construction and integration of suitable systems to realise an appropriate environmental control to test a broad range of aircraft structures and systems with respect to their thermodynamic behaviour.

Background

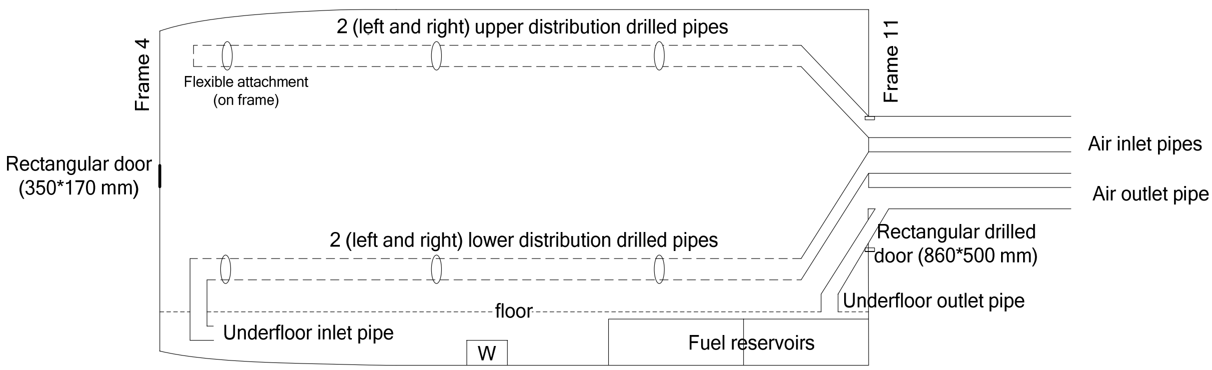
The core of the existing Test Facility is a 30 m long tubular low-pressure chamber with a diameter of 9.6 m. The first approximately 12 m of this pressure vessel, which is accessible through a 2.7 m x 3.0 m gate, are available for installations of the ground thermal test bench. To lift heavy equipment four 10 t cranes are installed inside the pressure vessel, they can move in longitudinal direction only. The floor of the laboratory outside the vessel is designed to carry loads of a forklift. The pressurisation currently is achieved inside the complete pressure vessel through three large vacuum pumps (Pneumofore UV50) of 90 kW and delivering 3240 m³/h each up to a certified differential pressure of max. 840 hPa (with outside absolute pressures of approx. 936 hPa at the laboratory, this yields ca. 100 hPa –the current system has been run at 150 hPa only, any operation below needs to be assessed by the applicant). The vessel itself has an air conditioning unit with a capacity of 9000 m³/h, 122 kW heating and 18 kW cooling power at a delivery pressure of 600 Pa under normal operation. It is possible to use this unit to remove heat and humidity generated inside the vessel, while considering heat gains through the outside environment (solar gains through transparent membrane roof construction per projected floor area of approximately 1350 kWh/m² - the vessel itself has a projected floor area of approximately 300 m²). Test items placed inside the vessel currently are supplied from outside the vessel via special grommets of which the following are available for the ground thermal test bench: 7x R2'', 1x DN100, 1x DN180, 7x DN200. Six Refrigeration compressors (Frascold / Z30-102.51Y) deliver R404a coolant which has cooling capacity down to approx. -46°C and may be used inside the vessel. For the current installation a control system based on Siemens Design Insight is available. Possibly based on this existing equipment a suitable solution for the thermodynamic conditioning of the ground thermal test bench system must be proposed.

For the ground thermal test bench the existent fuselage mock-ups must be used, which will have interfaces for conditioned air, electricity and measurement equipment and will be installed inside the low pressure vessel of the test facility near Holzkirchen, Germany. They will be equipped for testing in a representative and realistic environment and will not be qualified. Modifications of their structure by the applicant will not be possible. Any interfacing with these parts needs approval of the CleanSky EDS members. The parts will have the following approximate grand data:

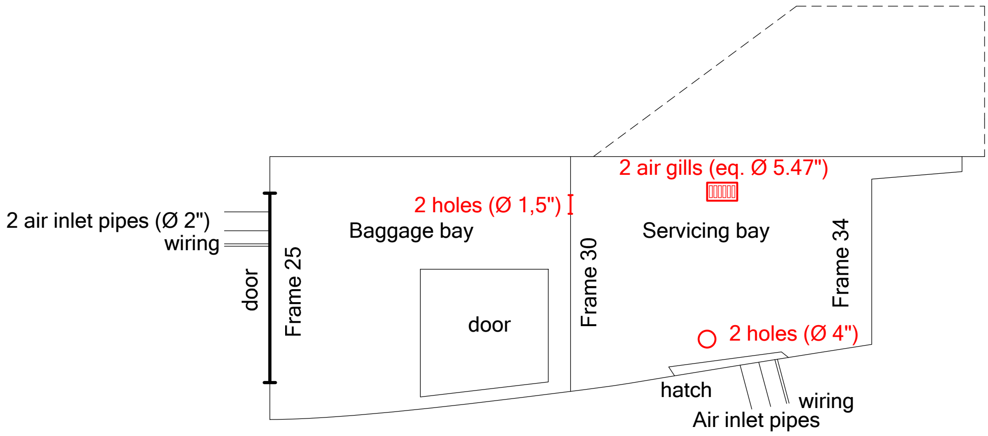
composite cockpit fuselage part (ca. 4 t with an internal volume of approx. 13 m³). This part has a 170 mm diameter plug at the rear frame through which air inlet and outlet pipes and wiring (power and sensors) can be installed. If needed, additional access can be provided through false windows (easily removable or drillable). The distribution pipes can be installed with flexible attachments to the frames.



Metallic cabin fuselage part (ca. 3 t with an internal volume of approx. 16 m³). This part has two hatches: one small (350*170 mm) at the front frame and one big (860*500 mm) at the rear frame. A false door can be manufactured and drilled for the rear hatch, in order to provide access to air inlet and outlet pipes, and wiring (power and sensors). The front hatch can also be used if needed. The distribution pipes can be installed with flexible attachments to the metallic frames.



Metallic aft fuselage part (ca. 4 t with an internal volume of approx. 14 m³). This part is made up of two technical bays: the baggage bay at the front (access through two false doors: cabin interior door, and side exterior door, which can be drilled to provide access to air inlet and outlet pipes, and wiring), and the servicing bay at the rear (access through either a centre-line hatch or bulkhead which can be drilled).



This description of the background of the thermal test bench is preliminary and must be discussed with the EDS members during the design phase.

Content

Aircraft and their systems are operating under a wide range of environmental conditions, several tests are defined e.g. in the guidelines DO-160 and MIL-810 and others, yielding the following maximum boundary conditions for equivalent flight conditions for the different parts which may be operated separately and conjointly:

		Fuselage parts	Aircraft calorimeter
Temperature	**Maximum**	85 °C (if possible, e.g. reduction to 80 °C may be necessary for some electric wiring)	150 °C
	Minimum	-55 °C	-65 °C
	Tolerance	± 2 K	
	Change rate	± 10 K/min (controlled in a range as wide as possible)	± 10 K/min (controlled in a range as wide as possible) thermal shock with > 100 K/min (often realised through a two chamber system) – desired
Pressure	**Range**	111 hPa to ambient (approximately 934 hPa)	
	Tolerance	± 5 %	
	Differential	None (same as vessel)	Up to 641 hPa – desired
	Change rate	max. ± 10 m/s (controlled climb / decent)	max. ± 10 m/s (controlled climb / descent) 641 hPa in less than 15 s (rapid decompression) – desired
Humidity	**Range**	Nearly 0 g/kg (at low temperatures) to 200 g/kg (g water per kg moist air)	
	Tolerance	± 5 % RH	
	Change rate	± 1 g/kg/min	
	Water quality	Resistivity of water for humidification: 0.15 – 5 MΩ at 25 °C	

Ventilation	Airflow velocity*	0 to 6 m/s (controlled)
	Airflow velocity* tolerance	± 10 %
	Mass flow	Up to 70 kg/min for all chambers/compartments of the bench separated in at least three differently conditioned flow sources (10 kg/min @ -55 °C to 70 °C; 30 kg/min @ 30 °C to 70 °C; 30 kg/min @ 3 °C to 20 °C). A detailed configuration of this amount, the pressure drop and the number of inlet and outlet pipes (ranging from 2 to 6 per fuselage part / ACC) shall be discussed and defined in a later stage with the EDS members.

* air velocity at specimen inside a chamber.

Each of these environmental conditions must be achieved in each of the thermal test bench components so that single items can be tested as well as full aircraft systems using above mentioned provided fuselage items of a business jet for several operational profiles of an aircraft. These may be typical profiles as well as failure cases which are under investigation towards an innovative energy management.

Air-conditioning units must be installed to provide moist air in proper thermodynamic conditions, i.e. with defined temperature, humidity and pressure. Test chambers as well as test objects must be provided with different flows. At least four to five different articles may be delivered with this air: the Aircraft Calorimeter, the aft fuselage part (two areas), the cabin fuselage and the cockpit fuselage. Additionally an external cooling/heating of the fuselage parts – e.g. by a cocoon, or inserted into a larger climate chamber with proper HVAC-interfaces supplied by the applicant – will be necessary to achieve realistic equivalent flight conditions. Optionally innovative thermal energy harvesting systems could be integrated.

The air-conditioning units do not need to supply fresh air, so an independent operation (except depressurisation) inside the pressure vessel is possible with no fresh air duct coming from normal pressure level. The units shall operate independently from already installed air-conditioning units in the "FTF-facility", a use of the installed refrigerating plant may still be possible.

For proper energy balance the leak tightness of ducts, flaps and valves shall be as high as possible (e.g. class D according to EN 13799). Mass flows shall be measured independently from or compensated with respect to pressure and temperature. All parts shall be interconnected so that thermodynamic flows between them are possible and controllable. Energy losses through these interconnections shall be compensated appropriately.

The aircraft calorimeter is to be supplied by the applicant. It shall be equipped with additional internal ventilators to ensure a proper convective heat transfer at the test article according to the test requirements. The test cell of the ACC shall be adiabatic, thus a wall heating / cooling system will be necessary to ensure proper thermal gradients and to avoid condensation in case of very humid conditions. To achieve test requirements regarding thermal shock tests a two chamber system may be necessary – this may be integrated in or additional to the ACC.

To gain the potential for decompression tests at least parts of the ACC could be executed for differential pressure operation of up to 641 hPa overpressure wrt the low-pressure environment inside the vessel. Depending on feasible openings and their control decompression experiments from cabin to low pressure in less than 15 s may be possible. The ACC and its core supply system shall be transportable on common container trucks. The ACC test cell shall thus have an outer dimension of approximately 2.3 x 2.3 x 4.6 m³ and an appropriate opening to enter specimens before and/or during test. At least for this system an air and/or water-cooling of the system components should be preferred.

The system must be mounted and integrated on site including sufficient interfaces, documentation and training to independently run and maintain the system in its full range. A suitable control system for bench automation and related data handling shall be implemented into the laboratories Design Insight software with appropriate GUIs. The ground thermal test bench shall be able to be operated 24 h a day with and without operating personnel (depending on test procedure). The applicant shall ensure a proper training of operating personnel until the system is fully operational. Up to this moment the operational sub-systems shall be run under the applicant's responsibility.

All equipment needed (incl. e.g. piping/ducts, valves, fans, ventilators, humidifiers and dehumidifiers, heating devices, pumps, electric motors, frequency changers, filters, mufflers, chillers, compressors, sensors and hard-/ software, air conditioning units, coolants, etc.) must be supplied and installed by the applicant. An exception is made for the fuselage parts themselves for which suitable air-conditioning interfaces must be provided. These are to be defined during the project lifetime. Power consumption of all relevant subsystems must be logged via an data acquisition system, e.g. via the test bench control system . For electrical installation and integration local resources at the laboratory will be available. The system must comply with VDE-guidelines and be included in the emergency shutdown system of the laboratory. In general the system at the laboratory site located in a mixed used area has to be compliant with German legislation. Installed materials and components used, including sensors, must be capable of the environmental range of the ground thermal test bench and moving parts must withstand an adequate number of cycles and must not contaminate the test equipment with abrasion compounds.

The work is conducted under the auspices of EDS work package 4.3 and the technical management therein. It entails handling innovatively low temperatures versus variable to high volumes, control algorithms and differential pressures. Therefore close liaison for technical and safety grounds is important.

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

Experience in planning, constructing and accomplishing projects in the area of heating, ventilation, air conditioning and refrigeration as well as vacuum technology.

Experience in developing unique test facilities for applying defined environmental conditions onto components and subsystems.

Experience in implementing and integration of suitable control strategies and interfaces.

8. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Development plan for Systems of Ground thermal test bench		T0+1M
D2	Preliminary Definition files for Systems of Ground thermal test bench for preliminary design review	Such as HVAC-Plans, wiring diagrams, etc.	T0+4M
D3	Definition files for Systems of Ground thermal test bench for critical design review	Such as HVAC-Plans, wiring diagrams, etc.	T0+7M
D4	Integrated Systems of the Aircraft Calorimeter of Ground thermal test bench	Integrated Systems are hardware, which is installed and running according to their specification	T0+18M
D5	Detailed documentation of the Aircraft Calorimeter of Ground thermal test bench	Manuals, Plans and Maintenance guidance	T0+19M
D6	Integrated Systems of the fuselage mock-ups of Ground thermal test bench	Integrated Systems are hardware, which is installed and running according to their specification	T0+22M
D7	Detailed documentation of Systems for the fuselage mock-ups of Ground thermal test bench	Manuals, Plans and Maintenance guidance	T0+23M
D8	Training of operating staff of Ground thermal test bench		T0+24M

9. Topic value (€)

The total value of this work package shall not exceed: **€ 1,700,000.—** **[one million seven hundred thousand euro]** Please note that VAT is not applicable in the frame of the CleanSky program.

10. Remarks

If applicable

Clean Sky - Green Regional Aircraft

Identification	ITD - AREA - TOPIC	topics	VALUE	MAX FUND
JTI-CS-GRA	**Clean Sky - Green Regional Aircraft**	**4**	**2.650.000**	**1.987.500**
JTI-CS-GRA-01	*Area-01 - Low weight configurations*			
JTI-CS-GRA-02	*Area-02 - Low noise configurations*		**150.000**	
JTI-CS-2010-4-GRA-02-013	Novel nose wheel evolution for noise reduction		150.000	
JTI-CS-GRA-03	*Area-03 - All electric aircraft*		**500.000**	
JTI-CS-2010-4-GRA-03-002	Energy Management – Electrical motors power control. Analytical studies and modeling		350.000	
JTI-CS-2010-4-GRA-03-003	Development of Numerical Models of Aircraft Systems to be used within the JTI/GRA Shared Simulation Environment		150.000	
JTI-CS-GRA-04	*Area-04 - Mission and trajectory Management*			
JTI-CS-GRA-05	*Area-05 - New configurations*		**2.000.000**	
JTI-CS-2010-4-GRA-05-005	Aero-acoustic noise emissions measure for advanced Regional Open Rotor A/C configuration.		2.000.000	

Topic Description

CfP topic number	Title		
JTI-CS-2010-4-GRA-02-013	**Novel nose wheel evolution for noise reduction**	**Start date**	*T0***
		End date	*T0 +12*

11. Topic Description

Short description

The topic of the present call for proposal is the development and manufacturing of noise influencing nose landing gear parts for investigation of NLG noise.

Abbreviations and Definitions

A/C Aircraft
CfP Call for proposal
GA Grant agreement
NLG Nose landing gear
WTT Wind tunnel test

1.1 Introduction

Retracted nose landing gears are one of the major contributors to A/C noise in takeoff and approach. Yet, development of noise reducing NLG elements impacts safety issues, especially to avoid loss of parts, possibly leading to fatal foreign object damage. Furthermore constraints of maintenance are of importance.

1.2 Reference documents

Not applicable

1.3 Scope of work

This CfP is related to the support of LNC WP2.2.4.3 Aim of the envisaged work is to enable experimental validation of noise reduction technologies for nose landing gears of regional aircraft in WTT by developing mechanical design and manufacturing of addional NLG parts.

1.4 Type of work

The work consists of and is organized as listed in the following tasks:

T1: The successful applicant has to make available a NLG including wheels representative in size, type and state of the art for regional A/C

T2: Definition of feasible WTT environment conditions and rough approximations for NLG flight and ground loads in cooperation with the Cleansky member

T3: Cooperative selection of most promising design variants for noise reducing additional NLG elements and mounting structures accordingly

T4: Detailed design of additional NLG elements and mounting structures, feasible for usage in defined WTT(most probably the member facility) and promising for later enhancement for usage in-flight tests; The design should nevertheless allow a fast and easy attachment and detachment of the additional parts for later WTT of the developed different variants and types as also for maintenance.

T5: Manufacturing of the developed parts of T4

T6: Information for actuation and handling of provided NLG in WTT environment are not mandatory but would be appreciated

T7: In case of special tooling needed for attachment and detachment of the additional parts, support for the following WTT is requested.

1.5 Requirements

Some sensitive information may be released only at a later date to the successful applicants. Other Requirements as noted in section two.

1.6 Other

Not applicable

1.7 Schedule, milestones and deliverables

T0: Kick-off meeting, delivery definition of NLG

T0+1: Cooperative definition of WTT environmental conditions, approximated flight and ground loads and selection of to be considered general layout variants

T0+3: Progress meeting 1 and report: design and manufacturing technology of noise reducing additional NLG elements

T0+6: Progress meeting 2 and report: design and manufacturing technology of mounting structures for attachment of the additional parts to the NLG

T0+8: Delivery of manufactured variants and types of noise reduction elements and mounting structures

T0+9: Final meeting and report

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

The applicant has to have a full EN 9001:2003 certificate.

Further required certificates are as follows:

- EASA Design Organization Approval according to part 21J
- EASA part 145 certificate including ratings for C6-Equipment, C12 Hydraulics, C14-Landing Gear, C17-Pneumatics and C20-Structure
- FAA certificate including the rating for landing gear components and nondestructive inspection, testing and processing
- An approval for at least the maintenance of this NLG according to the regulations of the national authorities of the EU member state is requested

The certification qualification shall be completed by the proven ability in the manufacturing and maintenance of aerospace components.

Furthermore proven skill and equipment for manufacturing of fibre reinforced plastics as also metallic components is requested.

13. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date**
D1	Nose landing gear	Nose landing gear delivery, described in section 1	T0
D2	Short Report 1	Short intermediate report on design and manufacturing technology of noise reducing additional nose landing gear elements	T0+3
D3	Short Report 2	Short intermediate report on design and manufacturing technology of the mounting structures	T0+6
D4	Manufacturing	Manufacturing of previously developed mounting structures and noise reducing parts	T0+8
D5	Final Report	Final report on design and manufacturing of developed Nose landing gear parts	T0+9

14. Topic value (€)

The total value of this work package shall not exceed: **150,000.--€** [One hundred and fifty thousand Euro] Please note that VAT is not applicable in the frame of the CleanSky programme. Funding will be from 50 to 75% of this maximum budget value. The total value of the activity is composed of manpower, equipment, expenses associated with the task.

15. Remarks

*** To and duration may be negotiated on the basis of the final JU time slots*
*The expected proposal length is assumed to be around **15 pages***

Topic Description

CfP topic number	Title		
JTI-CS-2010-4-GRA-03-002	**Energy Management – Electrical motors power control. Analytical studies and modelling.**	Start date	To ** *(March/2011)*
		End date	T0+12M

Note (**): T0 is the effective date of contract

16. Topic Description

Within the innovative Energy Management system technologies, it is important to analyse the behaviour of electrical motors used in the aircraft actuation systems, as well as the associated power controls. These controls shall allow to modulate the power demanded by the motor during each operating phase in order to reduce the power required from the aircraft generation system that should be used to provide extra power during transient condition to essential/critical loads.

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

- to perform analytical studies concerning the different types of motors and their typical equations,
- to provide mathematical models of each type of studied motor,
- to integrate the motor drive electronics (including power control techniques) within the motor models,
- to define the optimal power control law for each type of studied motor.

INTRODUCTION

Due to the on-board growing number and power of electromechanical actuators and overall electric loads on aircrafts, efficacious supervision and management control strategies are necessary in order to reduce the energy consumption and to optimize weight and volume of on-board electric generation and distribution system.

In order to develop these control strategies, it is necessary to know the operating modes of all the electrical and electromechanical loads (i.e. time-behaviours of speed, torque, power). For the different electrical devices and apparatuses, it is also fundamental to set-up mathematical models suitable to be effectively managed in a hierarchized control system. These models to point out should be sufficiently valid to describe the different operating conditions of the considered energy conversion systems; at the same time, they have to be sufficiently simplified in order to be really useful for the evaluation of energetic and power quality performance.

The attention should be mainly focused on analysing and modelling the different electric drives and the related energy storage apparatuses, which are utilized or which are going to be used on aircrafts.

Analysis and modelling activities should be oriented to the single main hardware parts of a drive (motors and power electronic converters) and also to the whole drive (including control techniques); obviously, specificities of drives for aircraft on-board applications have to be taken into account.

DETAILED DESCRIPTION

ELECTRIC MOTORS MODELLING

By referring to the instantaneous values of the electric, magnetic and mechanical quantities, mathematical models should be setup for the different motors used in on-board electric drives, in order to describe transient and steady-state operating conditions.

The attention should be mainly devoted to *induction motors* (IM) and *permanent magnet synchronous motors* (PM-SM); moreover, models of *variable reluctance synchronous motors* (VR-SM) and *switched reluctance motors* (SRM) have to be pointed out.

All the considered motors are brushless; reference should be made to three-phase and single-phase armature windings for IM, three-phase for both PM-SM and VR-SM. Mathematical models in steady-state operating conditions should be derived from the previous ones for all the analysed motors.

Different machine lay-outs have to be considered. In particular, for PM-SM the candidate should refer to either magnetically isotropic and anisotropic air-gap configuration; for the same motors radial-flux topologies have to be analysed and compared to radial-flux ones, which frequently have greater torque-density values (greater torque/volume ratios). Specificity of transverse-flux PM-SM should be also highlighted.

For VR-SM, flux-barrier and axially-laminated rotors have to be mainly considered for modelling procedures.

It has to be underlined the influence on the models of the non-linearity of the magnetic circuits and of iron-losses, taking into account the typical high-frequency values used in aeronautic applications and the consequent reduced sizes of the electric machines.

For all kinds of examined motors, the so-called “multiphase” configurations have to be analysed in order to improve intrinsic reliability and fault-tolerance of the motor.

Furthermore, PM motors with *iron-less rotor* have to be analysed in order to point out their mathematical model.

In order to obtain equations which can be easily handled and suitably used into real-time control algorithms, mathematical model with “concentrated parameters” have to be setup. Finite Element Methods (FEM) have to be used in order to improve the validity of the mathematical models. Especially for PM-SM and VR-SM, by means of FEM techniques different sets of motor parameters can be obtained and tabled in correspondence of different operating conditions. These tabled parameter values can favour adaptive control techniques, which can better exploit the motor characteristics in limit or critical operating conditions.

Motor parameter identification

Procedures have to be defined for the identification of the motor parameters values which are used in the mathematical models. Both off-line and on-line identification procedures have to be considered. The greater accuracy achievable with off-line tests should allow the definition of different sets of parameters corresponding to different operating conditions. The off-line parameter evaluation should also take into account the influence of other variables, as temperature, non-uniform current distribution in cross-section of conductors supplied by alternating current, non-linearity and saturation of air-gap and leakage magnetic circuits, non-negligibility of iron losses in some cases.

STATIC CONVERTERS OF ELECTRIC ENERGY

For the objectives of the project, simple models of static converters can be setup, considering the possibility to use switching devices very close to “ideal” ones, owing to the low power levels of on-board applications. Turn-on, turn-off and dead-times must be simply simulated in the converter models.

Basically, voltage source inverters (VSI) with pulse-width modulation (PWM) have to be considered for ac supplying of previously described electric motors. IGBTs and MOSFETs are the reference power electronic devices. Methods should be developed for evaluation of conduction mode and switching losses of the different converter devices.

Configurations with three levels (or still more voltage levels) have to be analysed in order to improve performance with respect to the conventional 2-level topology, in terms of reduction of current distortion, power quality, energy losses and electromagnetic compatibility. Neutral point clamped (NPC) topology could be the preferred three-level configuration. Cascaded H-bridge topology can be selected for several voltage levels.

Space-vector modulation techniques have to be dealt with, either for two or three levels converters, as well as sinusoidal PWM techniques with triangular carriers.

Over modulation behaviour has to be taken into account.

Besides of pure inverters, analysis and model of the two-stage dc-ac converters (dc/dc converter + dc link + inverter) have to be carried out.

The presence of a braking resistor in the dc-link can be modelled to simulate the dynamic braking phase of the drive.

ELECTRIC DRIVES

Starting from the basic considerations and modelling of the above mentioned electric motors and converter topologies, the simulation models of the different electric drives have to be developed exploiting several control techniques.

IM Drives

The objective is the setup of models able to describe the time-behaviour of the induction motor drives and the functional correlations among the significant variables, when field-oriented vector control (FOC) is used, with orientation on the rotor-flux space-vector. “Indirect” and “direct” feed-back configurations have to be separately analysed. Referring in both cases to a “current control algorithm”, the presence of hysteresis current controllers should be considered as well as PI controllers, linked to a voltage space-vector modulation.

The simulation models of the drives should be developed with reference either to torque-control or to speed-control.

Besides the FOC algorithms, also Direct Torque Control (DTC) techniques have to be exploited, referring either to the basic solution (the most suitable voltage-vector is selected and kept constant in each sampling interval) or to enhanced ones, which combine the look-up selecting tables of the basic DTC, with simple and suitable modulation technique of the inverter voltage.

Two and three levels VSI should be an optional choice for each considered control scheme.

PM-SM brushless drives

Modelling and simulation of PM synchronous drives should be developed using vector control techniques, based on a current algorithm and space-vector modulation of the VSI voltages.

Control algorithms specifically oriented to isotropic and anisotropic brushless motors are separately considered.

The simulation models of the drives should be developed with reference either to torque-control or to speed-control or to position-control.

Particular attention has to be devoted to operating conditions in the flux-weakening region, by developing energy-optimized control algorithms.

High values of torque/volume ratios are typical of PM brushless motors for aeronautic applications, whose magnetic circuits are consequently very stressed. Motor parameters (especially direct and quadrature magnetizing inductances) are sensible to the load conditions. Adaptive control techniques give rise to faster and more precise results and should be properly modelled, referring to look-up tables of the motor inductances built-on by means of FEM analysis or, more suitably, by means of proper laboratory(bench) tests.

Starting and braking operations should be properly modelled.

Required arrangements have to be pointed out for controlled drives using axial-flux PM motors.

Critical conditions of direct-drives should be evidenced with respect to geared drives, especially with regards to modification of feeding and control algorithms.

Finally, stability analysis has to be performed using classical methodology derived from technical literature.

SENSORLESS CONTROL

In addition to the control techniques based on measurement of the rotor speed by means of suitable sensors (i.e. absolute or incremental encoders, resolvers), the so-called speed-sensorless drives have to be considered either for induction motor drives or for permanent-magnet synchronous motor drives.

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

The Candidate organization shall have:

- a well recognized background on electrical actuation and power electronics (Theoretical Research Centre to be preferred),
- expertise in aircraft electrical system design (power generation, power conversion, power network, power consumer),
- extensive experience and know-how on SABER multi-physics tool (availability of a full code license),
- Good practice in English language.

18. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Analytical studies	Analytical studies concerning the different types of motors and their typical equations	T0 + 2M
D2	Mathematical models	Mathematical models of each type of studied motor (SABER tool to be used)	T0 + 5M
D3	Motor drive integration	Integration within the motor models of the motor drive electronics	T0 + 8M
D4	Optimal control law	Definition of the optimal power control law for each type of studied motor	T0 + 11M
D5	Summary report	Final summary report	T0 + 12M

19. Topic value (€)

The value of this topic is estimated in **350,000/00 €**
[three hundred fifty thousand euro

20. Remarks

None.

Topic Description

CfP topic number	Title		
JTI-CS-2010-4-GRA-03-003	**Development of numerical models of aircraft systems to be used within the JTI/GRA Shared Simulation Environment**	**Start date***	*T0*
		End date**	*T0+8(M)*

21. Topic Description

***Short description**:*

The CfP requires the development of numerical models for the simulation of the static and dynamic performances of the on-board systems of an all-electric regional aircraft, with particular focus on electrical loads. The models shall be based on physical-mathematical descriptions of A/C systems dynamic behaviour, and they shall be characterised by a adequate level of detail. In addition, the CfP requires the capability of the models to be integrated into the Shared Simulation Environment (SSE) developed within WP 3.2, whose main objective is to test and validate the energy management logics used for the optimization of the on-board electrical power.

1.1 Introduction

1.1.1 Background

The CfP will cover applied researches which are part of WP 3.2, titled “Technology for Systems”, of the All Electric Aircraft Domain (AEA, GRA3). In the current technological frame, different power sources (electrical, hydraulic, mechanical, pneumatic) are derived from propulsion systems for supplying on-board systems. In the “all electric” technological frame, all on-board systems will be electrically-powered. This solution clearly causes power absorption issues for electrical generators, which can be overcome only with the development of appropriate logics for the energy management.

The WP 3.2 aims at the selection and adaptation of tools and methods suitable for Energy Management System (EMS) design and simulation. Such tools have to be optimized in order to implement a Shared Simulation Environment (SSE) able to reproduce the system functions and performance. Mission profiles, obtained by an off-line flight simulator, will be used to generate SSE inputs in terms of commands, loads, operative modes, mission phases and environmental conditions. The dynamic simulation of the energy exchanges for particular mission profiles is needed for testing and validating the EMS logics. The EMS regulates the energy absorption of A/C systems through the modulation of the power supplied to each system. Such a power can be reduced, for systems that are not safety-critical, to control the total energy absorption.

Within WP 3.2, the activities which are organized into three tasks:

- task 1 <u>System Design Tools Selection</u>: selection and adaptation of tools and methods for system design and simulation at different stages of the design workflow
- task 2 <u>Development of a Shared Simulation Environment (SSE)</u>: implementation of a shared simulation platform for evaluation of all-electric Energy Management strategies by using multi-physics simulation tools
- task 3 <u>Development of Thermal Architecture Model of regional aircraft</u>: development of a thermodynamic model of aircraft for cabin temperature simulation.

The CfP will cover some activities to be performed in tasks 1 and 2. The selected applicant will operate in close collaboration with the CfP proponent and other WP 3.2 participants.

1.1.2 Interfaces to ITD:

The inputs to the selected applicant will be handled by the CfP proponent and will consist in technical report illustrating the requirements of each model to be developed within the CfP itself, in terms of model input/output, model complexity (physical phenomena to be taken into account) and model parameters (data changeable by the user). At present, it is not possible to precisely define A/C architecture, thus some assumptions may be initially necessary, to be done in agreement between the applicant and the CfP proponent. Further details will be provided by the CfP proponent before starting, and during the activity.

The outputs provided by the selected applicant shall consist in technical reports and numerical models to be delivered in the form of source codes. For each model, proper test vectors files shall be provided, together with a main routine that allows the model to be run and tested. The capability of the models to be integrated in a single simulation code shall be also demonstrated by the applicant.

The technical reports shall consist of:

- a Modelling Manual
- a User Manual
- a Check Manual

The first document shall describe the physical-mathematical models used for the model development as well as the implemented numerical algorithms, together with the structure and the organisation of the software. The second document shall provide the instructions to the user to run the models. The third document shall provide the instructions to run the test vectors.

1.3 Scope of work:

The result of the CfP shall be the development of numerical models of the following aircraft systems to be used in the SSE:

- Flight Control System
- Landing Gear System

The models shall provide a detailed characterization of the system components dynamics for accurate energy consumption analyses, network stability and electrical power quality studies. Each A/C system model shall be designed as a combination of nonlinear dynamic models, transfer functions or performance maps, relating the model inputs to thermal, mechanical, and electrical output energy flows.

<u>Flight Control System</u>

The models shall simulate the power absorption and the thermal flow related to the flight control actuators, the control computers and the sensors as a function of: actuator commands, EMS power supply, and operating and environmental conditions. In addition, performance parameters characterizing the actuators dynamics shall also be available.

The flight control system model shall be developed with reference to the systems features and the architecture of the future All Electric green regional Aircraft (AEA), which will be provided by the CfP proponent. This includes:

1) Primary flight controls:
   - Ailerons and steering spoilers for roll control
   - Elevators for pitch control
   - Rudder for yaw control
2) Secondary flight controls:
   - inboard and outboard flaps

The flight control system will be equipped with Electro-Mechanical Actuators (EMA), each one composed of a 3-phase synchronous brushless motor connected with a low-pitch screw jack. The number of EMAs, computers and sensors composing the flight control system will be defined by the CfP proponent according to the redundancy level required for the GRA application.

The model shall take into account the actual kinematics of the systems, the inertial loads and the dynamics of the EMAs. The evaluation of the aerodynamic forces acting on the control surfaces - as functions of A/C flight conditions - shall be included in the models. The aerodynamic coefficients needed for the calculation of such aerodynamic forces will be provided by the CfP proponent in the form of look-up-tables which will account for the changes in the coefficients with surface deflection, A/C angle of attack and Mach number.

Input signals: flight parameters (A/C speed and altitude), actuator commands (i.e. position demand), power supply from EMS to each actuator, local air temperatures

Output signals: power absorptions, thermal flows, actuators position, motors current, actuators temperature.

Landing Gear System

The model shall simulate the extension/retraction power absorption of a classical tricycle Landing Gear (LG) as a function of extraction / retraction stroke, environmental conditions and A/C speed. The extension-retraction is powered by (EMA).

The model shall be developed with reference to the LG architecture of the future AEA, which will be provided by the CfP proponent. This includes:

- a model of the actual load transfer (weight and aerodynamic forces) to the EMA, depending on the LG extraction / retraction stroke;
- a model of the actual kinematic link between position and velocity of the EMA rod and angular position and velocity of landing gear during extraction / retraction;
- an model of the EMA behaviour that includes the dynamic peaks of power absorption when starting the extraction and the retraction.

The aerodynamic coefficients needed for the calculation of the aerodynamic forces on the LG will be provided by the CfP proponent in the form of look-up-tables which will account for the changes in the coefficients with LG extraction / retraction stroke and A/C angle of attack.

Input signals: A/C speed and angular velocities, air density, pilot command (extraction / retraction), power supply from EMS.

Output signals: LG angular velocities and positions (and / or EMAs strokes), power absorptions.

1.4 Type of work:

Development of numerical models for dynamic simulation of electrical power consumption of some systems of an all-electrical aircraft, and issue of support manuals.

1.5 Requirements:

The models shall be developed taking into account that their final scope is to be integrated within a SSE, where they will work together with other models developed by the CfP proponent. In addition, the models shall be developed in a modular form, so that the CfP proponent can easily modify and update the subsystems models, and the related input parameters, accordingly with the development of the GRA project. A requirement for a future integration of the SSE with an external optimisation tool shall be also addressed.

For traceability purposes, input parameters, as well as the main output data, shall be preferably treated through text files, properly organised and commented.

Specific tools for the post-processing of simulation data (e.g. time histories of inputs and outputs) shall be also developed and provided.

Although the applicant is free to select the most appropriate simulation environment for developing the models, an object-oriented approach is recommended. In addition, it is required the capability of the models to be integrated within both AMESim and Modelica/Dymola platforms.

If applicant-proprietary tools have to be used for models modification or simulation run, the applicant shall provide the CfP proponent with tool licences, that will cover the whole duration of the GRA project.

1.6 Customer Support:

The applicant shall provide customer support for a period of no less than 6 months from the date when the SW is delivered in its final form. Customer support activities to be performed by the applicant shall include user familiarization with the tool, resolution of software problems (bugs), minor changes to improve GUI or functionality.

1.7 Schedule, milestones and meetings:

A kick-off meeting (KOM), two progress meeting (PM) and a final meeting (FM) will be scheduled at the topic manager site. They will coincide with critical milestones (M). The activities will be developed as defined by the following schedule:

Time	meeting	milestone	Description
T0	KOM		Definition of the detailed work program
T0+2	PM1	M1	Definition of the models requirements and architecture
T0+6	PM2	M2	Preliminary releases of simulation models
T0+8	FM1	M3	Final releases of simulation models and support documentation

The expected length of the proposal is assumed to be 12 pages.

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

Due to the short duration of the activities, the proposal should address clear indications of the resources, in terms of personnel, simulation software and computational power, the applicant will use to carry out the work. The applicant is expected to have experience in dynamic modelling and simulation of the aircraft systems

23. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Models design document	• Report describing the architectural, functional and performance requirements of the models, together with a preliminary physical-mathematical descriptions	T0+2
D2	Preliminary version of simulation models and related reports	• Preliminary version of simulation models • Reports documenting models features (Modelling Manual and User Manual in a draft version)	T0+6
D3	Simulation models and support documentation	• Refined simulation models • Two reports documenting models features (Modelling Manual and User Manual) • A report documenting tests results (Check Manual)	T0+8

24. Topic value (K€)

The Maximum Allowed Topic Budget is

150,000 €

[one hundred fifty thousand euro]

The maximum funding value is between 50% and 75% of the Maximum allowed Topic Budget indicated above according to the CfP rules.

25. Remarks

(*) The start date (T0) might be adjusted according to the status of the activities of WP 3.2 and/or to the availability of inputs from other WPs.

(**) A reference duration of 8 months is foreseen, nevertheless a modest increase, up to a maximum of 4 weeks, might be negotiable if status of WP 3.2 would permit.

Topic Description

CfP topic number	Title		
JTI-CS-2010-4-GRA-05-005	**Aero-acoustic noise emissions measure for advanced Regional Open Rotor A/C configuration.**	**Start date**	T0 (**)
		End date	T0 + 15 months

Note (**): T0 is the effective date of contract

26. Topic Description

Short description

It is required an aero-acoustic noise measurement of an Open Rotor advanced Regional A/C configuration which enables the creation of an aeroacustic data base in order to:

- o allow the validation of Alenia aero-acoustic simulation codes;
- o assess installative effects of the OR engine on the aircraft noise.

This measurements will be performed in an aero-acoustic Wind Tunnel Test Facility using a modular model that allows to reproduce different engine positioning and configurations, and different flight conditions.

1.1 Introduction

1.1.1 Background

Within the “New Configuration” (NC) Project of the Green Regional Aircraft ITD, new green A/C configurations are addressed tailored to future regional airliners, by taking into account 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 will be pursued along the NC by the main NC task objectives:
- Define the requirements for the new GREEN regional A/C
- Design new configurations accomplishing such requirements
- Integrate at A/C level technologies from GRA domains to reduce NOISE and EMISSIONS
- Demonstrate the features of the most promising configurations.

1.2 Scope of work

The object of the present work is to perform aero-acoustic measurements of an Open Rotor aircraft configuration emitted noise and installation effects due to the reflective action of aircraft body. Such measurements will be performed in a wind tunnel test facility on a scaled model.

1.3 Type of work

Wind Tunnel Model design and manufacturing of an OR a/c configuration, wind tunnel tests execution for aero-acoustic measurements, database creation of OR engines noise emission and installation effects on a/c, data analysis for far-field and near-field noise characterization.

1.4 Abbreviations & Definitions

3D	Three-Dimensional
A/C	Aircraft
ACARE	Advisory Council for Aerospace in Europe
AoA	Angle of attack
AP	Approach
CAD	Computer Aid Design
CF	Center Fuselage
GRA	green Regional Aircraft
ITD	Integrated Technology Demonstrator
NC	New Configuration
OASPL	Overall Sound Pressure Level
OB	Octave Band
OR	Open Rotor

RF	Rear Fuselage
SPL	Sound Pressure Level
T Tail	Tail with T geometry
TBL	Turbulent Boundary Layer
TO	Take Off
TVT	T shaped (T) Vertical Tail (VT)
U Tail	Tail with U geometry

1.5 Description of Work

According to the objectives described in par. 1.2, the concerned activity will be developed through the following tasks

Task 1 – Multi-configuration Model Design

Task 2 – Multi-configuration Model Manufacturing

Task 3 – Wind Tunnel Test Campaign

Task 4 – Aero-acoustic measurements analysis

Each task is defined as follows.

1.5.1 Task1 – Multi-configuration Model Design

Task 1 will concern with the design of the model that will be used for the wind tunnel activity.

Model scale has been set 1:7.5. This value balances the opposite needs of reaching propeller or rotor dimensions still enabling adequate test conditions and, on the opposite side, to contain engine simulator power requirement.

Resulting model span/length is 4500, 5560 mm

In the proposal, the capability of reducing the number of parts to be manufactured by using same part for different configurations (e.g.: the fuselage) shall be carefully weighted against the increase in part complexity in order to avoid lengthy handling during the configuration changes involved in the tests.

Essential requirement is that the model is designed to avoid deformation during tests.

The model shall allow testing of the following configurations:

<u>**Pusher OR**</u>

a) Baseline wing with leading edge and trailing edge deflected.

b) Front Fuselage and Centre Fuselage with Low Set Wing

c) Rear Fuselage able to be set in two different axial positions with respect to Front Fuselage / Centre Fuselage / baseline wing low set assembly

d) Fuselage Engine Pylons able to be set in two different rotation values (Baseline, B1) and three radial spans (Baseline C1, C2) as per following Fig.1;

e) T Tail able to be set in two different axial positions with respect to Rear Fuselage / Engine Pylons assembly.

f) Engine Simulators set at Engine Pylons end.

g) Nose and Main Landing Gear.

h) U Tail aimed to verify engine shielding effect

Tractor OR

a) Baseline wing with leading edge and trailing edge deflected.

b) Front Fuselage and Centre Fuselage with Low Set Wing

c) Rear Fuselage able to be set in two different axial positions with respect to Front Fuselage / Centre Fuselage / baseline wing low set assembly

d) Fuselage Engine Pylons able to be set in two different rotation values (Baseline, B1) and three radial spans (Baseline C1, C2) as per following Fig.1;

e) T Tail (TVT) able to be set in two different axial positions with respect to Rear Fuselage / Engine Pylons assembly.

f) Engine Simulators set at Engine Pylons end.

g) Nose and Main Landing Gear.

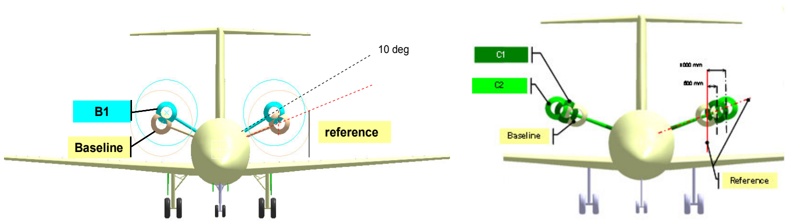


Fig. 1

Wing Mounted Engine

a) Baseline wing with leading edge and trailing edge deflected.

b) Front Fuselage and Centre Fuselage with High Set Wing

c) Rear Fuselage able to be set in two different axial positions with respect to Front Fuselage / Centre Fuselage / baseline wing assembly

d) Wing Engine Pylons able to be set in two different axial locations (Baseline, FWD)

e) T Tail able to be set in two different axial positions with respect to Rear Fuselage and Engine Pylons assembly.

f) Engine Simulators set on Wing Engine Pylons.

g) Nose and Main Landing Gear.

Within the task 1 it is required:

- to characterize the engine simulator to match the propeller characteristics (to design if necessary)

- to design the gearbox connecting the engine with the propeller.

- to developed the propeller/rotor blades scaled to 1:7,5.

The model installation into the Wind Tunnel Facility must be considered and properly designed in order to allow model angle of attack variations, possibility to perform emitted noise, by means of beamforming technique, on one side of the model and below it.

Inputs:

GRA-ITD will provide

CATIA V5 file of reference geometry to be used for model design;

The list of all modifications to the baseline configuration

Sizing loading;

Blade geometry drawings (1:1 scale);

Outputs:

Detailed 3D CATIA V5 file of test model geometry complete with all details necessary for manufacturing; (**D1.1)**

Detailed 3D CATIA V5 of test model – wind tunnel interface; **(D1.2)**

Technical report - with model structural verifications, weight and balance data, assembly and configuration changes procedure, instrumentation interfaces; **(D1.3)**

Detailed 3D CATIA V5 of engine parts and assembly **(D1.4)**

1.5.2 Task 2 – Multi-configuration Model Manufacturing

The test model will be manufactured according to the model design of Task 1.

Two engines will be manufactured according to inputs provided in Task 1 and engine design. In particular, responsibility of this task is the manufacturing of blades, gearboxes, nacelles and provide the installation of electric engines, control unit, cabling and wirings together with their connections.

Parts for testing of the isolated propulsion system simulator (Engine, Gearbox and Propeller) will be manufactured.
Model installation in the wind tunnel test facility.

Inputs:

GRA-ITD will provide

Manufacturing tolerances;

Target weight;

Outputs:

Test model hardware (**D2.1)**

2 engines complete of blades, nacelles, electric engine, gearbox, control unit, cabling and wirings **(D2.2)**

Technical report – Test model description and quality verification including positive checks on tolerances covering all the configuration required **(D2.3)**

Technical report – Wind Tunnel Test facility description and (a cosa serve?) model installation description **(D2.4)**

1.5.3 Task 3 – Wind Tunnel Test Acoustic Campaign

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

The following test matrix will be performed (see fig.1):

1. Wind tunnel background noise @ 5 different velocities.
2. Isolated propulsion system simulator noise (Pusher OR, Tractor OR, Propeller) @ 3 different velocities, 3 different AoA, 2 power settings (TO, AP)
3. Installed (Pusher OR) baseline configuration @ 3 velocities, 3 AoA, engines OFF
4. Installed (Pusher OR) baseline configuration @ 3 velocities, 3 AoA, 2 power settings (TO, AP)
5. Installed (Pusher OR) B1 configuration @ 3 velocities, 3 AoA, 2 power settings (TO, AP)

6. Installed (Pusher OR) C1 configuration @ 3 velocities, 3 AoA, 2 power settings (TO, AP)
7. Installed (Pusher OR) C2 configuration @ 3 velocities, 3 AoA, 2 power settings (TO, AP)
8. Installed (Pusher OR) T Tail_2 configuration @ 3 velocities, 3 AoA, 2 power settings (TO, AP)
9. Installed (Pusher OR) RF-CF position_2 configuration @ 3 velocities, 3 AoA, 2 power settings (TO, AP)
10. Installed (Pusher OR) U Tail configuration @ 3 velocities, 3 AoA, 2 power settings (TO, AP)
11. Installed (Tractor OR) baseline configuration @ 3 velocities, 3 AoA, 2 power settings (TO, AP)
12. Installed (Tractor OR) B1 configuration @ 3 velocities, 3 AoA, 2 power settings (TO, AP)
13. Installed (Tractor OR) C1 configuration @ 3 velocities, 3 AoA, 2 power settings (TO, AP)
14. Installed (Tractor OR) C2 configuration @ 3 velocities, 3 AoA, 2 power settings (TO, AP)
15. Installed (Tractor OR) T Tail_2 configuration @ 3 velocities, 3 AoA, 2 power settings (TO, AP)
16. Installed (Tractor OR) RF-CF position_2 configuration @ 3 velocities, 3 AoA, 2 power settings (TO, AP)
17. Installed (Propeller) baseline configuration @ 3 velocities, 3 AoA, 2 power settings (TO, AP)

Type of measurements

FAR-FIELD NOISE 13 microphones located out-of-flow on a polar arc centred on the blade-plane (step of 10 degrees)

NEAR-FIELD NOISE 9 microphones located in-flow close to the engine (mic. array moving in x-dir. relative to blade-plane)

BLADE NOISE SOURCE ~ 10 kulite sensors flash mounted on 1 blade per row and per engine

FUSELAGE NOISE SOURCE ~ 30 kulite sensors flash mounted on skin fuselage close to the 1st blade row (forward position)

EMITTED NOISE emission noise map by means of beamforming measurement on 1 side and below the model (emitted noise on ground)

MODEL INSTALLATION VIBRATION 2 accelerometers on model-wind tunnel interface

For test type 1 far-field noise measurements will be made

For test type 2 far-field noise and blade noise source measurements will be made

For test type 3-18, all measurements will be made.

Inputs:

Alenia will provide

Complete and detailed Test Matrix with all conditions

Wind tunnel settings (velocities), a/c settings (AoA), engine settings

Outputs:

Test Plan **(D3.1)**

Test Report (**D3.2)**

1.5.4 Task 4 – Aero-acoustic measurements analysis

Acquired data will be analysed in order to obtain

1/3 OB SPL, OASPL, A weighted-OASPL; at each microphone of far-field and near-field set.

auto-Spectra, cross-Spectra, Coherence, turbulent boundary layer characterization for kulites

Emitted Noise map on model, for the identification of noise sources, in the beamforming measure

Inputs:

No inputs are considered

Outputs:

Technical Report – Acoustic characterisation of far-field and near-field noise **(D4.1)**

Technical Report – TBL noise characterisation on blade and fuselage (**D4.2)**

Technical Report – Acoustic test analysis: effects of fuselage and engine installation on engine noise generation (**D4.3)**

Technical Report – Parametric study of engine positions respect to generated noise (**D4.4)**

1.6 Requirements

Sensitive information may be released at a later date to the successful applicant.

1.7 Milestones

M1 (T_0 + 3 months):
Release of 3D geometry of test model complete with all details necessary to manufacturing (deliv. D1.1)

M2 (T_0 + 5 months):
Release of engine model (deliverable D1.4)

M3 (T_0 + 7 months)
Wind Tunnel acoustic Test Plan (deliverable D3.1)

M4 (T_0 + 15 months)
Acoustic test data analysis (deliverables D4.3 & 4.4)

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.

27. Major deliverables and schedule – T_0 (currently foreseen): January 2011

Deliverable	Title	Description (if applicable)	Due date
D1.1	Detailed 3D CATIA V5 file of test model complete with all details necessary for manufacturing;		T_0 + 3 months
D1.2	Detailed 3D CATIA V5 of test model – wind tunnel interface		T_0 + 3 months
D1.3	Technical report – model structural verifications, mass and balance, configuration changes procedure, instrumentation interfaces		T_0 + 3 months
D1.4	Detailed 3D CATIA V5 of engine simulator parts and assembly		T_0 + 5 months
D2.1	Test model hardware		T_0 + 8 months
D2.2	2 engines complete of blades, nacelles, electric engine, gearbox, control unit, cabling and wirings		T_0 + 8 months
D2.3	Technical report – Test model description and quality verification including positive checks on tolerances covering all the configuration required		T_0 + 9 months
D2.4	Technical report – model installation description		T_0 + 9 months
D3.1	Test Plan		T_0 + 7 months
D3.2	Test Report		T_0 + 12 months
D4.1	Technical Report – Acoustic characterisation of far-field and near-field noise		T_0 + 14 months
D4.2	Technical Report – TBL noise characterisation on blade and fuselage		T_0 + 14 months
D4.3	Technical Report – Acoustic test analysis: effects of fuselage and engine installation on engine noise generation		T_0 + 15 months
D4.4	Technical Report – Parametric study of engine positions respect to generated noise		T_0 + 15 months

28. Topic value (K€)

2,000,000.00 €

[two millions euro]

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

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

29. Remarks

N/A

Clean Sky - Green Rotorcraft

Identification	ITD - AREA - TOPIC	topics	VALUE	MAX FUND
JTI-CS-GRC	**Clean Sky - Green Rotorcraft**	**3**	**1.165.000**	**873.750**
JTI-CS-GRC-01	*Area-01 - Innovative Rotor Blades*		**575.000**	
JTI-CS-2010-4-GRC-01-005	Gurney flap actuator and mechanism for a full scale helicopter rotor blade		575.000	
JTI-CS-GRC-02	*Area-02 - Reduced Drag of rotorcraft*		**590.000**	
JTI-CS-2010-4-GRC-02-003	Contribution to optimisation of heavy helicopter engine installation design		440.000	
JTI-CS-2010-4-GRC-02-006	Helicopter hub and fuselage drag investigation by means of hybrid URANS/LES methods		150.000	
JTI-CS-GRC-03	*Area-03 - Integration of innovative electrical systems*			
JTI-CS-GRC-04	*Area-04 - Installation of diesel engines on light helicopters*			
JTI-CS-GRC-05	*Area-05 - Environmentally friendly flight paths*			

Topic Description

CfP topic number	Title		
JTI-CS-2010-4-GRC-01-005	***Gurney flap actuator and mechanism for a full scale helicopter rotor blade (fixed blade wind tunnel testing and rotating blade whirl tower testing)***	**End date**	T0+58 M
		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 of the blade, more usually on the lower blade surface. The AGF is essentially a Gurney flap with the ability to alter its height from zero (fully retracted) to maximum (fully operative). Its impact upon the performance of an aerofoil can thus be varied and controlled. On a helicopter rotor blade the aerodynamic requirements change as the blade moves around the azimuth from the blade advancing to blade retreating condition. The AGF offers the possibility of 'conditioning' the performance of the rotor blades to match these changing requirements by using a pre-determined schedule of operation (ie progressively extended/retracted) as the blade rotates around the helicopter.

In order to assess the capabilities of an AGF system it is intended that system demonstrators be manufactured, trialled and evaluated. These start with the testing of an AGF system embedded into a section of rotor blade that itself is mounted in a fixed position in a wind tunnel (blade static testing). Here it will be possible to determine, under controlled conditions, the AGF's influence upon the basic performance of a helicopter main rotor blade. This same technology will then be fitted to a donor production standard helicopter blade and whirl tested on ground rigs (whirl towers) where its capabilities under representative aerodynamic and dynamic conditions will be assessed.

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 an AGF system intended for both of the intended tests.

2. Scope of work:

In order to design and manufacture the requisite ART test specimens the Green Rotorcraft Consortium members wish to engage with a company (or consortium) who will collaborate with existing Green Rotorcraft Consortium members to support the design of an AGF system that is to be integrated into: 1) a segment of actual helicopter main rotor blade for wind tunnel testing (blade fixed in position whilst the AGF is activated) and subsequently 2) using predominantly the same mechanism and blade design to produce a fully functional flight worthy rotor blade with 'active' capabilities (whirl tower tested). The net requirements requested of the bidding companies are:

a) In conjunction with the Topic Manager to design an AGF system suitable for inclusion into a helicopter main rotor blade to be used for ground based testing.

b) Design, development, manufacturing, test and supply of hardware for the deployable active Gurney flap(s) to be located within or flush to the structure of the blade, following advice and rules provided by the Topic Manager.
c) Included are the provision of an actuator and driving mechanism (contained within the blade profile), both assumed to be electrical in nature and capable of forcing the AGF to its commanded position.
d) A method for determining the actual (achieved) position of the AGF relative to its desired (commanded) position.
e) Provision of electronic/electrical control of the actuator to allow it to fulfil its intended function. This component will be supplied with low level electrical inputs that it must convert into positional commands to be sent to the AGF, thereby moving the Gurney Flap to its desired position.

These components will be subjected to the following programmes of test:

a) <u>Static blade wind tunnel test</u>

The AGF mechanism will be incorporated into a helicopter main rotor blade structure manufactured from composite materials, typically having a 0.45 m chord (aerofoil section) and 1.0 m or greater active region span (total blade span could be longer) and with an AGF embodied along the active span region. The AGF mechanism and controlling systems will have to undergo the following and other tests:

Structural and endurance testing by the bidder to prove suitability for purpose and compliance with specification, both as individual components and when embodied in the blade test sections

Low speed wind tunnel testing

b). **<u>GRC1 Whirl test – full scale helicopter rotor blade</u>**

The AGF mechanism will be fitted into a standard helicopter main rotor blade of composite material construction with minimal disruption of the blade structure or degradation of the blade's capability. The blade chord will be typically about 0.45 m whilst the length of operating Gurney flap (blade spanwise extent) has yet to be determined. It is possible that the AGF will have to be made in more than one segment but with each segment expected to be commanded to the same operating schedule.
The AGF mechanism and controlling systems will have to undergo the following and other tests:

Structural tests (additional in need to those described above), performance and endurance testing by the bidder to prove suitability for purpose and compliance with specification. This will include proof that the Gurney Flap mechanism can survive and operate in the rotating blade (high CF) environment.

Whirling tests on a rotor blade whirl rig (comparable to a blade fitted to an actual helicopter) with open loop control of the deployable AGF. Closed loop control may also be considered but will be reviewed at a later date.

Expectation from the bidder

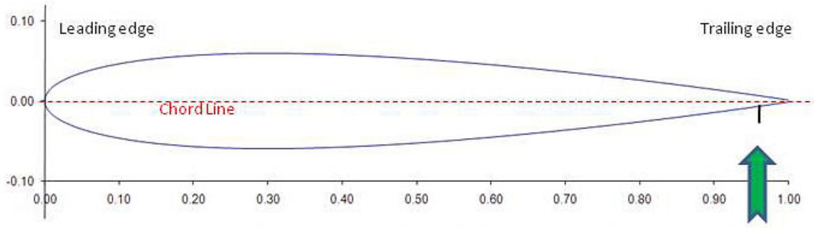
The bidder, amongst other things, will be required to:

- Provide a detailed *Supplier Specification* for the actuation system in response to the Topic

Manager's *Requirements Specification.*

- Design critical elements of the AGF system (defined in a) to e) in the scope of work above) in collaboration with GRC1 members.
- Produce and demonstrate prototype AGF system(s) with characterised performance via appropriate test of their key components, notably their force providing actuator/mechanism.
- Deliver complete actuated Gurney Flap systems for integration into composite main rotor blade specimens.

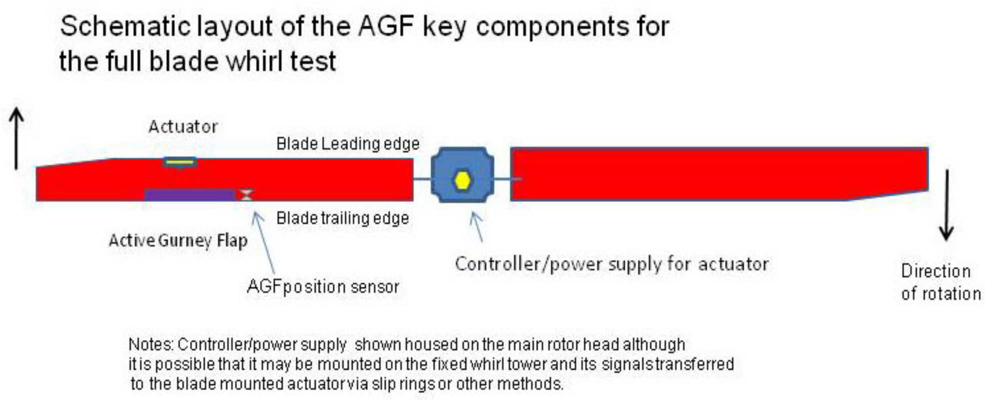
Note: The GRC-1 will provide rotor blade and helicopter rotor head interface details at the start of the programme.



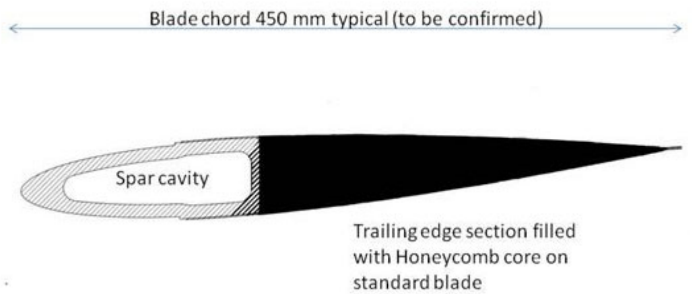
Leading Particulars:

1. The AGF is defined as being a fully retractable structure that when activated (by an actuator) protrudes from the lower blade surface of a helicopter rotor blade in the trailing edge location. The flap is deployed perpendicularly to the blade's chord line [a straight line from the front (leading edge) limit to the aft (trailing edge) limit of the aerofoil section]
2. The required height of the fully deployed flap is dependent upon its proximity to the extreme trailing edge tab. The closer it is, the smaller its height may be, consequently the objective is to locate the flap as closely to the aft extremity of the trailing edge tab as is realistically possible. This however depends upon practical rotor blade constraints. In practice, the AGF is only of value if located at the extreme trailing edge (95%+ of the chord dimension as measured from the leading edge of the blade).
3. The height of the flap is specified in terms of the ratio of the blade's aerofoil section's maximum thickness (or depth) to chord (length) or t/c. The exact t/c value required will be dependent upon various factors but would be expected to be 2% or less.
4. The AGF will be deployed once per blade revolution using pre-determined schedules of operation. These may be harmonic (progressive extension /retraction) or non harmonic (rapid deployment, hold in position, rapid retraction).
5. Current expectations are that the tests will be in open loop configuration. A command signal will be used to set the actuator to a desired height according to where the rotor blade is in relation to its travel around the rotor azimuth. The achieved height of the Gurney flap is constantly monitored and compared to the expected (commanded) height. In such an open loop configuration the output of the sensor used to monitor the actual height of the Gurney flap will not be used to instruct the control system or make adjustments to the control system output signals to the actuation mechanism. However the possibility of progressing to a closed loop configuration whereby such feedback systems constantly monitor <u>and adjusts</u> AGF height (in order to ensure that the achieved height of the AGF consistently matches the demanded height) remains an option.
6. It is anticipated that the AGF, its status sensor and associated actuation system will be located within the blade whilst the controlling electronics will be housed separately and connected via

electrical wires. For the full blade whirl test the AGF will be located in the outer third (spanwise) section of the blade.



7. Depending upon feasibility, the deployable Gurney Flap could be either a) a mechanism that deploys from within the blade section. Severe physical space constraints have to be considered. b) Devices that lie across or flat (flush) to the blade surface and increase in height (chordwise, spanwise or other orientation) c) other options. The design of this mechanism is a key element of this package of work and must meet with the general needs of a rotor blade's design and operation as detailed in the Requirements Specification Document. This document will be provided once the selected bidder has signed the relevant agreement proposed within the frame of this contract to protect the confidentiality of data exchanged..
8. The winning bidder would be expected to present design concepts of its intended mechanism(s) to the GRC1 consortium for preliminary approval ahead of full design/ test.
9. The loads to be overcome by the actuation mechanism in deploying the AGF will depend upon deployment strategy. Devices that lie flat to the blade surface are likely to be dominated by air loads, whereas a mechanism that deploys downwards from within the blade will be dominated by friction. *As an example theoretical case, for a Gurney flap of 1m length, depth of 2% t/c ratio and located at 100% blade chord: Peak Gurney Flap Load (drag) is approx. 250 N, Peak Gurney Flap Root Moment approximately 1.5 N m* (note - these numbers are indicative only, do not form any part of a formal specification and are subject to alteration)
10. A Requirements Specification (RS) covering the selection of materials, mechanical loading conditions and operating environment etc. will be supplied. The use of non aerospace materials will need agreement.
11. For the full rotor blade whirl tower testing activity the components of the AGF mechanism located within the blade will have to withstand centrifugal force (CF) loads in the order of 600G and also blade vibratory loads. It is possible that the other remaining elements of the AGF system (eg power electronics) may also be located in the rotating environment but at the rotor head, and thus with a significantly lower CF loading.
12. The wind tunnel demonstrator rotor blade section will be a generic design, probably having a public domain aerofoil section such as NACA 0012 and with a blade chord of typically 450 mm.



13. The actuator mechanism that drives the moving Gurney Flap system must respect the operational temperature limit of the materials used for rotor blade construction. This will be defined. Note that the actuator will be contained within the closed environment of a rotor blade spar.
14. Rotor blade mass and chordwise weight distributions are critical. Mass in total has to be strictly controlled (minimised) as the whirl test blade will have to comply with strict centrifugal force CF limits.
15. Rotor blades are chordwise balanced at the 25% chord (measured from the aerofoil leading edge). Mass added to the trailing edge of the blade should thus be kept to a minimum as it would need to be balanced with significant additional mass, possibly parasitic, in the nose region. This creates a significant net weight penalty that could be at issue with 14 above.
16. For the key electrical components of the AGF system (actuator and controlling electronics) it is strongly desired that the technology used is proven hardware/software and ideally a derivative of production or existing components/technology that need minimal change. Ideally the actuator and its controlling electronics will have been proven in combination. Proof will be sought.
17. More detailed guidance will be provided at the start of the task.
18. Operational frequency of deployment of the AGF is in the region of 5 to 15 Hz.
19. Costs of operation of the wind tunnel (2D tests) and the Whirl tower are borne by the GRC 1 programme hence do not have to be considered by the bidders. Monitoring of the behaviour and performance of the AGF, and any necessary revisions of the AGF during these tests will however be the responsibility of the bidder. A specific quotation for the support requested during those phases (eg resources allocation) planed from T0+40 until T0+58 will be provided separately in the proposal released.

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

1. The applicant should be able to design, manufacture and provide a) an actuation system to move a deployable/retractable Gurney flap b) associated and matched means for electrically powering the actuator c) a deployable Gurney flap to be incorporated into an existing design of a helicopter rotor blade, with design assistance being provided by the GRC1 and d) a method for recording accurately the activated status of the flap relative to its commanded system.
2. It is anticipated that the above defined system elements, and most particularly the actuator and its controlling electrical/electronic systems, will be based upon current, proven components/knowledge wherever possible, evidence for which will be sought and vetted for suitability.
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) spares for the primary test objectives described in the scope of work c) all other necessary qualification and test activities that arise.
4. The winning bidder will be expected to provide, at any stage as requested by the GRC-1, technical documents, drawings and descriptions of the developed hardware, electrical systems and copies of any operating software.

5. The hardware components that have to be incorporated within the rotor blade sections (Gurney Flap mechanism and its actuator as a minimum) will need to take account of restrictions of size, mass and operating temperatures etc. dictated by helicopter rotor blade design. System efficiency is therefore important.
6. Although the hardware will be used for ground based testing and demonstration, the applicant would be expected to demonstrate compliance with both a provided set of general aerospace requirements and also dedicated individual component requirements for each of the component parts of the AGF system. Evidence that the applicant can design and produce components to aerospace standards will be sought at bidder selection.
7. It is desirable that the applicants would be capable of progressing their final AGF system through to a future flight demonstrator activity should this work progress in that direction.

3. 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	Detailed supplier Specification	Detailed supplier specification for the AGF system in response to D0	T_0 + 3 months
D2	Detailed Design review (Preliminary Design Review – PDR)	Confirm status/suitability of developing design of the AGF components.	T_0 + 9 months
D3	Critical Design Review - CDR	Detailed critical review of the AGF system including (but not limited to): design drawings and reports/ performance estimates of the constituent parts of the AGF/ performance estimates of the overall system/. This will cover mechanical and electrical components together with any software should it be desired for the functioning of the AGF.	T_0 + 12 months
D4	First Prototype system delivery	Supply of all relevant components to produce prototype AGF system (s) to be incorporated within a rotor blade (or representation).	T_0 + 17 months
D5	Review suitability of AGF for integration into wind tunnel test specimens and working main rotor blade	Demonstration by design review, supporting documents, test evidence etc. as requested by GRC1 consortium and/or topic manager.	T_0 + 17 months
D6	Revised prototype system including modifications resulting from review process and from lessons leant from testing	Supply of all relevant components to produce a refined AGF system(s) to be incorporated within a rotor blade (or representation).	T_0 + 20 months
D7	AGF system for blade integration – Wind tunnel test	Supply and fitting of all relevant components to produce four off AGF systems to be incorporated within rotor blades for wind tunnel testing.	T_0 + 24 months
D8	Confirm suitability of functioning AGF system for integration into a working main rotor blade	Evidence from wind tunnel test specimen assembly and actual tests to be used to confirm a) system functionality and b) suitability for incorporation into a functioning main rotor blade. AGF components to be subsequently modified to overcome any shortfalls in capability/non compliance to meet the needs of all tests	T_0 + 26 months
D9	AGF system for integration into a fully functioning main rotor	Supply of all relevant components to produce a refined AGF system (2 off) to be incorporated within a helicopter main rotor blade intended for	T_0 + 30 months

	blade for whirl tower testing	whirl tower testing	
D10	Compliance evaluation – whirl tower testing Revised equipment to be supplied if non compliance occurs	Confirmation that the AGF system components are functionally fit for purpose ahead of blade whirling and subsequently operate correctly during whirl tower installation trials. Revised equipment to be supplied if non compliance occurs.	T_0 + 40 months
D11	Final report	Detailed final report of tasks undertaken.	T_0 + 58 months

Note: The above table does not account for AGF system and component needs with respect to any evaluation or qualification testing, development activities etc.

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

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:

€ 575 000/00 (VAT not applicable)

[five hundred seventy five thousand euro]

5. Remarks

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

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

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

- The expected length of the technical proposal is assumed to be 25 pages *with individual chapters for each of the key elements a) to e) defined in the scope of work.*

Topic Description

CfP topic number	Title		
JTI-CS-2010-4-GRC-02-003	***Contribution to optimisation of heavy helicopter engine installation design.***	**End date**	T0 +24 months
		Start date	1st Jan 2011 (T0)

1. Topic Description

<u>1. Background:</u>

Within the Heavy Helicopter activity it is envisaged that a contribution will be required from an outside organisation in order to support the GRC2 consortium, specifically in order to optimize engine installations using existing methods of simulation. The main goal will be to maximise helicopter performance and to reduce both fuel burn and noise. Engine installations usually take the generic form of an air intake, engine bay cooling system, exhaust system, and inlet partical separator system, all of which will be subject to potential re-design as part of the optimization process.

<u>2. Scope of work:</u>

Aerodynamic design constraints will include: minimising inlet pressure loss and distortion; minimising backpressure on the engine; engine bay cooling; avoidance of tailboom heating; avoidence of hot gas re-ingestion; minimizing fuselage drag etc. Further geometical contraints, imposed in order to ensure that the resulting design remains practically viable, will need to respect engine, drive train and airframe structures. Other constraints will include structural integrity and weight considerations.

It is envisaged that current state-of-the-art design search and optimization [DSO] techniques (ie, highly-computation based parameterized design-of-experiments [DOE] methods), sensitivity-based approaches and Adjoint methods will all be considered as potential integrated packages. Specifically, the applicant shall use CATIA® and ANSYS/FLUENT® proprietary software for geometry manipulation and CFD mesh generation. The main output of the entire process will be the development of optimization techniques specifically tailored to this application; initial geometry, validated CFD cases and optimization constraints for novel intake & exhaust concepts will be provided by the topic manager in CATIA® and ANSYS/FLUENT® formats and the successful applicant will be engaged in the setup, analysis and optimization of the concepts. The optimisation will focus on the intake geometry and the exhaust geometry, although the engine bay cooling intakes and inlet particle separator system may also be investigated. The culmination of this work will be a comparative assessment of the resulting optimized concepts, both against each other and the datum design, this will highlight the potential for improvement that would be available for practical helicopter designs.

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

Successful applicants will have a qualified and demonstrable skill set in aerodynamic and CFD disciplines and a track-record in relevant industry sectors. Evidence of publications in the relevant journals or forums would be a good indicator of expertise in the field. An intimate and working knowledge of the following commercial packages is expected: CATIA®, HYPERWORKS®, GAMBIT®, TGRID® and FLUENT®. All software used must be compatible with that used by the industrial partner.

In addition, any software developed within this package must be made available as source code to the lead partner.

3. Major deliverables and schedule

Deliverable	Title	Short Description (if applicable)	Due date (month)
D1	Dependant on optimization scheme adopted: Fundamental constraints of problem identified and smaller 'trial' problem/project initiated.	Release of: • Initial trial problem results • All input and output geometry and CFD software files	T0 + 3m
D2	Engine installation problem constrained and scope of solutions identified. Eg. For DOE methodology, experiment map completed and optimized.	Release of: • Stage 1 Report • First set of 'optimized' geometries • All input and output geometry and CFD software files	T0 + 9m
D3	Further development of selected design(s) geometry and CFD simulation. Including scope to include other departments, eg. stress and therefore further refinement of new or current project.	Release of: • Stage 2 Report • All input and output geometry and CFD software files	T0 + 18m
D4	Quantification of benefits and recommendations.	Release of: • Final Report • All input and output geometry and CFD software files	T0 + 24m

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:

€ 440 000.00 (VAT not applicable)

[four hundred forty thousand euro]

5. Remarks

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

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

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

- The expected maximum length of the technical proposal is not limited.

Topic Description

CfP topic number	Title		
JTI-CS-2010-4-GRC-02-006	**Helicopter hub and fuselage drag investigation by means of hybrid URANS/LES methods**	**End date**	T_0 + 24 months
		Start date	T_0

1. Topic Description

1. Background:

In the frame of the Green Rotorcraft ITD (GRC), the sub-project GRC2 "Drag reduction of airframe and non-lifting rotating systems" aims among others at improving the aerodynamic characteristics of helicopter fuselages and rotor-heads.

Both the analysis and optimisation activities in GRC2 make use of experimental tests (wind-tunnel and free flight) as well as numerical simulations of the flow-field around and of the aerodynamic characteristics of the configurations considered. The optimisation part aims mainly at drag reduction and characterisation of interactional effects.

Presently widely spread in the industrial context and used within GRC2 are Computational Fluid Dynamics (CFD) software packages that model turbulence in the context of the unsteady Reynolds-averaged Navier-Stokes equations (URANS). However this approach still suffers from accuracy penalties for massively separated and highly unsteady flows as in the wake of blunt aft-bodies and rotor-heads. Recently made available for challenging applications too, the approach of hybrid URANS/LES combining the advantages of URANS and large eddy simulation (LES) looks most promising in terms of prediction accuracy.

The successful applicant (Partner) shall support the GRC Consortium in the aerodynamic analysis of the fuselage and rotor head of a helicopter of the light weight class.

2. Scope of work:

The purpose of this topic is twofold:

- To contribute to the analysis of an existing fuselage and rotor-head geometry (provided by the GRC Consortium), especially in terms of areodynamic loads and interactional effects. At most three flight attitudes will be considered.
- To provide data helping the GRC Consortium determine whether hybrid URANS/LES turbulence modelling is applicable in industrial processes.

The work proposed is purely of numerical simulation type using CFD in combination with advanced hybrid URANS/LES turbulence models.

Input (from the GRC Consortium):

- Input 1:

The full scale geometry of the helicopter configuration will be provided in CATIA V5 format and will consist of a fuselage with landing skids and a rotor-head. All parts will be simplified so as to exhibit a water-tight smooth surface.

If useful and upon request from the Partner, already existing grids may also be provided.

Flight cases will be specified too.

- Input 2:

Specifications for the post-processing will be provided so as to maximise benefits for the GRC Consortium.

Among others, the following aspects will be considered: breakdown of forces and moments over components; Fourier analysis of forces and moments; unsteady and time-averaged analysis of the surface flow solution; Fourier analysis of the pressure distribution on the surface; unsteady and time-averaged analysis of the flow-field, especially behind the backdoor and the rotor-head down to rear control surfaces. Interactional effects will be part of the analysis. Further, the analysis is to show differences in the results between RANS, URANS and hybrid URANS/LES run modes.

The format of the data to be delivered to the GRC Consortium will be specified too.

• Input 3 (optional):

Dependig on the availability of experimental data from another GRC2 task, the GRC Consortium may decide to provide the Partner with wind-tunnel data to compare with. In any case, the computations will be performed in blind mode.

Task 1: Analysis without rotor-head

For the flight cases considered (2 or 3), two computations are to be carried out: one on the fuselage alone and one on the fuselage with landing skids. Each computation is to be started in RANS mode, then restarted in URANS mode and finally completed in hybrid URANS/LES mode, which shall show the gradation between these three approaches. This represents a maximum of six computations without rotating parts.

Post-processing is to be done as specified by input 2.

Task 2: Analysis with rotating rotor-head

For the flight cases considered (2 or 3), one computation is to be carried out on the fuselage with landing skids and with rotating rotor-head. Each computation is to be started in URANS mode and then completed in hybrid URANS/LES mode, which shall show the gradation between these two approaches. This represents a maximum of three computations with rotating parts.

Post-processing is to be done as specified by input 2.

Output (from the Partner):

A report and the computation results in digital form are to be delivered at the end of each task. The report of task 2 will be an augmented version of the first one. Both reports will be submitted for approval by the GRC Consortium who may require modifications or additions.

The final report is meant as an exhaustive documentaton of the topic, for instance, containing a description of:

• the geometry;

• the numerics: grids, flow solver, numerical set-up, computer used, numerical convergence, computational times, any specific feature of the hybrid URANS/LES turbulence modelling;

• the flow solution: forces and moments, surface flow solution, flow-field solution;

• the aerodynamic analysis: sensitivities w.r.t. angle of attack; fuselage/rotor-head interactional effects (localisation and quantification); characterisation of the aerodynamic excitation at rear control surfaces.

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

• demonstrated expertise in CFD, especially in advanced turbulence modelling (hybrid URANS/LES)
• experience with simulations on helicopter configurations
• capability for simulating body components in relative motions
• availability of an incompressible flow solver would be of advantage
• capability for a statistical/Fourier analysis of quantities
• access to (very) large compute resources

3. Major deliverables and schedule

Deliverable	Title	Short Description (if applicable)	Due date (month)
I1	helicopter geometry and flight cases	• CATIA V5 file of the geometry • optional: already existing grids • flight cases	$T_0 + 1$
I2	post-processing specifications	• items to be post-processed • format of data to be delivered	$T_0 + 3$
D1	analysis without rotor-head (task 1)	• first version of the report • first set of results data	$T_0 + 12$
I3	experimental data	I3 is optional	$T_0 + 23$
D2	analysis with rotating rotor-head (task 2)	• completed version of the report • complete set of results data	$T_0 + 24$

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:

€ 150 000 (VAT not applicable)

(hundred fifty thousand euro)

5. Remarks

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

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

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

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

Clean Sky - Sustainable and Green Engines

Identification	ITD - AREA - TOPIC	topics	VALUE	MAX FUND
JTI-CS-SAGE	**Clean Sky - Sustainable and Green Engines**	**10**	**7,950,000**	**5,962,500**
JTI-CS-SAGE-01	*Area-01 - Geared Open Rotor*			
JTI-CS-SAGE-02	*Area-02 - Direct Drive Open Rotor*			
JTI-CS-SAGE-03	*Area-03 - Large 3-shaft turbofan*		**3,800,000**	
JTI-CS-2010-4-SAGE-03-003	High Efficiency Fuel Pumping		1,500,000	
JTI-CS-2010-4-SAGE-03-004	Fuel Control System Sensors and Effectors		1,300,000	
JTI-CS-2010-4-SAGE-03-005	High Temperature Electronics		1,500,000	
JTI-CS-2010-4-SAGE-03-006	Ring Rolling of IN718		1,000,000	
JTI-CS-SAGE-04	*Area-04 - Geared Turbofan*		**4,150,000**	
JTI-CS-2010-4-SAGE-04-001	Development of low cost near conventional hot die forging process for gamma-TiAl low pressure turbine blades		650,000	
JTI-CS-2010-4-SAGE-04-002	Development of near net shape isothermal forging process for gamma-TiAl low pressure turbine blades		600,000	
JTI-CS-2010-4-SAGE-04-003	Development and validation of an integrated methodology to establish future production concepts		1,000,000	
JTI-CS-2010-4-SAGE-04-004	Development of low cost casting process for gamma - TiAl billets		550,000	
JTI-CS-2010-4-SAGE-04-005	Development & Manufacture of High Temperature Carbon Fibre Reinforced Plastic (CFRP) Aero engine Parts for Continuous Use at Temperatures above 350°C		850,000	
JTI-CS-2010-4-SAGE-04-006	Machining of highly stressed components: Development of Precise Electrochemical Machining (PECM) Simulation		500,000	

Topic Description

CfP topic number	Title		
JTI-CS-2010-4-SAGE-03-003	**High Efficiency Fuel Pumping**	**Start date**	*Jan 2011*
		End date	*Dec 2012*

30. Topic Description

The SAGE3 project aims to develop and demonstrate large, high bypass engine technologies that deliver higher efficiency and lower emissions, helping to reduce the environmental impact of aviation. A technology element with respect to increasing engine efficiency will be the realisation of small diameter engine cores; allowing the accomodation of traditionally fancase mounted units onto the engine core to enable nacelle aerodynamic and bypass flow improvements.

Smaller engine cores in combination with evolving engine architectures and advanced cycles will increase the overall heat mangement challenge. Heat management system optimisation and particularly fuel temperature control will be a key enabler with respect to realisation of the above, with efficiency of fuel system components being an important factor.

High efficiency fuel pumping is seen as a key element within future heat management solutions, providing a direct route to reducing heat input to fuel, together with an opportunity to reduce size and weight of the unit and associated drive system. Additionally, greater demands are being placed upon fuel pumping capability by growing requirements from complex control functions and other secondary flow demands.

From the above it is clear fuel pumping technological challenges are many-fold; delivering high efficiency, advanced functionality and reliability whilst operating in a more demanding environment and meeting exacting cost and weight targets.

Variable displacement pumping is regarded as a potential solution, combining the reduction of high pressure fuel flow re-circulation with a capability to manage secondary flow demands; though likely to challenged by other requirements.

In this context, a short-term research project is foreseen to design and demonstrate a fuel pumping solution satisfying the following requirements.

- Deliver fuel in line with engine demand with minimum heat input to fuel: temperature rise <15°C
- Provide maximum fuel flow rate of 40,000lb per hour at 2200psi
- Operational environment surrounding air temperature up to 200°C
- Manage HP fuel temperatures of 150°C, with excursions to 200°C
- Pressure cycling 2300 psig @ 80°C for 120,000 cycles
- Pressure ripple of less than 2%
- Minimum overhaul life of 30,000 hours
- Reliability of 300,000 hours Mean Time Between Failure
- Maximum weight of 50lbs

Future fuel pumping solutions should consider whole life costs and must address REACH and other mandatory legislation.

The partner shall in particular perform the following tasks:

Task 1: Concept Definition

Define solution concept to include design, analysis and testing of key components and materials.

Task 2: Detailed Design and Procurement

Perform detailed design and procurement of components.

Task 3: Verification

Undertake assembly, functional performance and environmental testing of the design(s) developed in Task 2 to the demonstrate compliance to requirements.

Task 4: Reporting

Produce summary reports, including recommendations for future exploitation and/or further technology development.

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

Extensive experience and pedigree in the design, development and manufacture of fuel pumping systems for high performance, safety critical applications is required. The successful applicant would be able to demonstrate in-service history of several products in this technology area. Experience of suitable quality control systems is essential.

The applicant or consortium shall have access to specialised system test and environmental facilities required to deliver meaningful demonstration of component capability.

Successful experience, with demonstrable benefits, of application of innovative manufacturing and component technologies to reduce weight and cost of aerospace parts is an asset.

The activity will be managed with a Phase and Gate approach and a management plan has to be provided. Rolls-Royce will approve gates and authorize progress to subsequent phases.

32. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1.1	Concept Definition	Review and Report	July 2011
D1.2	Key Component and Materials	Report	June 2011
D2	Detailed Design	Design Report Schematics Detail Drawings	Jan 2012
D3.1	Test Programme	Test Plan	Sep 2011
D3.2	Test Results	Test Programme Report	Nov 2012
D4.1	Technology Implementation	A report providing an overview of : – Pump integration requirements – Product cost and weight implications – Further technology development requirements	Dec 2012
D5.1	Project Completion	Project Summary Report	Dec 2012

33. Topic value (€)

€ 1.5 M
[one million 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.

34. Remarks

If applicable

Topic Description

CfP topic number	Title		
JTI-CS-2010-4-SAGE-03-004	**Fuel Control System Sensors and Effectors**	**Start date**	*Jan 2011*
		End date	*Dec 2013*

35. Topic Description

The SAGE3 project aims to develop and demonstrate large, high bypass engine technologies that deliver higher efficiency and lower emissions, helping to reduce the environmental impact of aviation. A technology element with respect to increasing engine efficiency will be the realisation of small diameter engine cores; allowing the accomodation of traditionally fancase mounted units onto the engine core to enable nacelle aerodynamic and bypass flow improvements.

This will place increasingly complex control system components, providing advanced fuel system functionality, within a harsher operating environment, whilst needing to deliver high levels of performance with increased reliability.

In order to meet these requirements it will be necessary to develop more capable control system sensor and effector suites, employing novel and emerging technologies to address the growing capability gap. The specific technological challenges are accurate position and flow measurement, and delivering the actuation requirements of increasingly complex control functions, using small, lightweight and affordable devices that are capable of operating in extreme environments.

Specific Requirements

Sensors:

- Continuous position measurement: e.g. fuel metering valves
  - Range 0 - 5mm and 0 - 20mm
  - Accuracy better than +/- 0.25% of range
- Proximity sensing: e.g. shut-off valves
  - Range 0 - 2.0mm
  - Accuracy better than +/- 5% range
- Mass flow measurement
  - Range from 50g/s to 5kg/s
  - Accuracy better than +/- 1% of point

Effectors:

- Linear and/or rotary direct drive: e.g. fuel metering valve control
  - Maximum linear force > 15kgf , maximum torque > 0.15 kgm
  - Maximum linear speed > 20 mm/s @ > 5 kgf
  - Maximum angular speed > 240^{o}/s @ >0.05 kgm
- Fuel metering valve servo-systems control

Environment:

- Operational temperature range: -54^{o}C to +200^{o}C
- Operational maximum pressure: 2,500 psi
- Vibration: 60G from 10Hz to 4kHz, limited to 1.3mm displacement
- Contaminated fuel testing where appropriate to MIL E 5007E table X

Life: > 25,000 operational hours

Reliability better than 1 x 10^{-7} failures per hour

Safety: Must not feature undetectable in-range failure modes

In this context, the following activities are required:

Laboratory demonstration of advanced capability relating to

- Fuel Valve Position Sensing
- Fuel Valve Proximity Sensing

- Fuel Mass Flow Measurement
- Fuel Valve Actuation (Effector)

Development of technology exploitation plans, including integration and implementation strategies that support application within the next-generation of high efficiency aero gas turbine engines.

Demonstration of technology capability utilising rigs to substantiate performance and durability within representative systems and environments.

The Partner shall in particular perform the following tasks:

Task 1: Technologies Review

In recent years, significant progress has been made in the development of new sensor and effector technologies in many different industries and operational environments, resulting in technology maturation within these applications and generation of large amounts of pertinent data. These technologies, and new and emerging sensor and effector technologies, should be reviewed to investigate their capability relative to aero gas turbine engine fuel control system measurement and actuation requirements.

Technologies identified as providing the required capability or offering improved performance relative to today's solutions shall be taken forward for laboratory demonstration.

Task 2: Laboratory Scale System Demonstration

Test arrangements representative of system implementations shall be designed to validate and demonstrate the capabilities of the device technologies identified within Task 1. Wherever possible, these experiments should look to employ off-the-shelf components. Where necessary new components and sub-systems shall be designed and manufactured to complete this task.

Task 3: Systems Environmental Demonstrators

Device technologies / system implementations successfully demonstrated in Task 2 shall be further developed to meet on-engine operational requirements and suitably demonstrated to prove the technologies are fit for purpose.

The new sensor and effector technologies should be incorporated into a fuel metering unit to demonstrate system integration and functional performance.

Aerospace applications place unique combinations of environmental requirements (e.g. parameter extremes, high rates of change and aggressive fluids) and demanding performance requirements (e.g. extreme operating pressures and high accuracy) on high integrity systems. The new sensor and effector technologies / control systems should be demonstrated in operationally representative environments (likely to be significantly different to the standards applied within the industries from which the technologies have been derived.)

The integrated systems demonstrators should be subjected to extreme functional and environmental rig testing, including, but not limited to:

- Extremes of temperature, temperature cycling and rapid thermal transients
- Vibration and shock loading
- High pressures and rapid pressure transients
- Rapid functional transients

Selected units shall be subjected to sustained endurance testing.

Task 4: Technology Implementation

A document shall be generated describing - the intended implemenations of the demonstrated technologies within specific engine control functions; the operational benefits to be realised through these implementations / functions; the cost implications of the technologies with respect to future control system solutions; remaining technology gaps and further development activity.

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

The applicant or consortium needs to have access to sensor and effector technology developed for operation in harsh environments.

Extensive experience and pedigree in the detail design, development and manufacture of high performance safety critical systems that utilise the technology is required. The successful applicant or consortium should be able to demonstrate in-service history of several products in this technology area. Experience of suitable quality control systems is essential.

It is key that technologies are selected and combined so as to achieve maximum benefits in an integrated system configuration. The applicant or consortium shall be responsible for definitions of integrated gas turbine engine systems that provide a route to exploitation for the demonstrated technologies. The applicant or consortium should possess both system design and integration capabilities, and also have access to the specialised system test facilities required to deliver meaningful demonstrators.

Successful experience, with demonstrable benefits, of the application of innovative manufacturing and component technologies to reduce weight and cost of aerospace parts is an asset.

The applicant or consortium needs to demonstrate access to the manufacturing facilities required to meet the above goals. The activities will be managed with a Phase and Gate approach and a management plan must be provided. Rolls-Royce will approve gates and authorize progress to subsequent phases.

37. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1.1	Initial Technologies Review	Description of technology landscape and identification / justification of those technologies selected for further development / demonstration.	June 2011
D1.2	Interim Technologies Review	Updated technology selection with justification.	Dec 2011
D1.3	Final Technologies Review	Final updated technology selection with justification, prior to final demonstrators.	Jun 2012
D2.1 to D2.x	Laboratory Scale Systems Demonstrator Design Reviews and Reports	Demonstrator reports shall be issued for all technologies demonstrated.	From Dec 2011
D3.1 to D3.x	Integrated Systems Environmental Demonstrator Design Reviews and Reports	Integrated systems design review and environmental test reports.	From Jun 2012
D4.1	Technology Implementation	A report providing an overview of: – How the sensor and effectors technologies would be implemented within engine control functionality – The benefits that will be delivered – The product cost implications of the technology Further technology development requirements	Dec 2013

38. Topic value (€)

€ 1.3 M
[one million three 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.

39. Remarks

If applicable

Topic Description

CfP topic number	Title		
JTI-CS-2010-4-SAGE-03-005	**High Temperature Electronics**	**Start date**	*Jan 2011*
		End date	*Sep 2012*

40. Topic Description

The SAGE3 project aims to develop and demonstrate large, high bypass engine technologies that deliver higher efficiency and lower emissions, helping to reduce the environmental impact of aviation. A technology element contributing to increasing engine efficiency will be the realisation of small diameter engine cores; allowing the accomodation of traditionally fancase mounted units onto the engine core to enable nacelle aerodynamic and bypass flow improvements.

Future control functionality requirements along with efforts to minimise the number of services / interconnections crossing the core to fancase boundary have the potential to drive a need to place electronic control components into a harsher operating environment, whilst continuing to demand high levels of performance and reliability.

To meet these requirements it will be necessary to develop high temperature control electronics capability. In order to deliver this capability there are a suite of technologies requiring development, including component selection, circuit and packaging design, and manufacturing processes. Definition and validation of accelerated test methodologies will be a significant element with respect to demonstrating operational life. Furthermore, whole life costs and accommodation of REACH and other mandatory legislation must be considered.

Emerging requirements include:

- Core-mounted electronics package capable of operating in a 'typical' environment of 250°C, with excursion to 300°C (thermal soak-back)
- Sensor signal conditioning circuitry capable of monitoring linear or rotary position (20mm travel, accuracy +/-0.05mm)
- Output circuits capable of driving servo-valves (50mA, 8V max)and solenoids (200mA, 40V max)
- Fault accommodation
- 25,000 hours operational life (minimum 5,000, ideally 10,000 thermal cycles)

In this context, a short-term research project is foreseen as follows:

- Capture details of the operational and on-engine environment requirements to inform the design and test processes.
- *Design high temperature control electronics circuitry to deliver the required functionality, including features to address the operational environment (e.g. cooling strategies) and safety criticality of the application (e.g. fault accommodation / reversionary modes.)
- Realise the circuit designs through the implementation of advanced packaging and processing technologies.
- Define and apply test methodologies that explore the performance, temperature characteristics and cyclic life capability of the circuit designs.

*Consideration will have to be given to the available high temperature component set and anticipated certification / legislation requirements.

The understanding gained through this project will identify the technology-gaps relative to delivering electronics capable of operating within the core-mounted environment of an aero gas turbine, informing the direction / focus of future research efforts.

The Partner shall in particular perform the following tasks:

Task 1: Capture the Operational and Environmental Requirements

Ellicit operational and operating environment requirements of core-mounted control electronics (e.g. reversionary modes, 'realistic' temperature cycles, vibration environment) for incorporation into the design and test elements of the project.

Task 2: Concept Design

Define design concept(s) that address the requirements from Task 1 within the constraints of component availability, legislation and certification.

Down select a design option to be taken forward for detail design, manufacture and test

Task 3: Detailed Design

Produce an electrical, mechanical and thermal design to realise the concept defined in Task 2:

- Source necessary components (e.g. active / passive devices, substrates).
- Evaluate alternative packaging / processing options
- Select preferred thermal management solution(s)

Task 4: Manufacture

Manufacture of the circuit design derived in Task 3:

- Apply chosen manufacturing processes to realise design

Task 5: Validation

Define and perform validation tests that demonstrate the capability of the design to meet requirements.

- Define the test methodology and ensure suitable test facilities are available
- Test high temperature electronic units (including circuits, components, substrates, assembly and packaging)
- Report results of testing

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

Extensive experience & predigree in the detail design, development and manufacture of electronics for for high performance, safety critical applications is required. The successful applicant would be able to demonstrate in-service history of real-time embedded electronics products operated in a harsh environment (e.g. mounted on a gas turbine engine.)

It is key that technologies are selected and combined so as to achieve maximum benefits in an integrated system configuration. The partner will be responsible for outline definitions of integrated engine level systems that will provide a route to exploitation for the demonstrated technologies. The partner will need to possess both system design and integration capabilities, and also have access to the special system test and environmental facilities required to deliver meaningful demonstrators.

The partner needs to demonstrate access to the manufacturing facilities required to meet the above goals.

Successful experience, with demonstrable benefits, of application of innovative manufacturing and component technologies to reduce weight and cost of aerospace parts is an asset.

Experience of suitable quality control systems is essential.

The activity will be managed with a Phase and Gate approach and a management plan has to be provided. Rolls-Royce will approve gates and authorize progress to subsequent phases.

42. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1.1	Operational and Environment Requirements Capture	Operational and Environment Requirements Capture Document	Feb 2011
D1.2	Environment & Operational Requirements Capture	Requirements Review	Feb 2011
D2.1	Concept Design	Concept Design Review	Apr 2011
D3.1	Detailed Design	Circuit Diagrams Layout Diagrams Manufacturing Process Definition	Sep 2011
D4.1	Manufacture	Prototype Product Release Report	Dec 2011
D5.1	Validation	Validation Plan	Oct 2011
D5.2	Validation	Validation Report	Aug 2012
D5.3	Technology Exploitation	A report providing an overview of: – How the technologies would be implemented – The product cost implications of the technology – Further technology development requirements	Sep 2012

43. Topic value (€)

€ 1.5 M
[one million 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.

44. Remarks

If applicable

Topic Description

CfP topic number	Title		
JTI-CS-2010-4-SAGE-03-006	**Ring Rolling of IN718**	**Start date**	*Jan. 2011*
		End date	*Dec. 2014*

45. Topic Description

The subject of this call for proposal is the development and validation of a **R**ing **R**olling (RR) alone route for disc manufacture in IN718 Superalloy. This manufacturing route is a potential alternative to the current standard, which depends to a higher or lesser extent on **C**lose **D**ie **F**orging (**CDF**).

This proposal covers two sets of complementary aspects. On one hand, it covers topics with a Manufacturing insight. On the other, it deals with issues which are relevant from an engineering viewpoint. The later is of particular importance in the case of discs as they are required to satisfy high demanding requirements in terms of integrity and life.

From the manufacturing standpoint, this project will require the development of a sound knowledge of the evolution of IN718 material structure as a result of continuous rolling. This will require generating both basic and experimental knowledge upon the effect of hot forming parameters on the resulting material (micro)structure. All manufacturing attempts shall target the best material usage (profiling or near-net shaping) so that this aspect is not longer a potential drawback when compared with CDF.

From an end-user viewpoint, this CfP will target demonstrating equivalence of both material structure and mechanical properties with that resulting from the current route, which does involve to a higher or lesser extent Close Die Forging. This activity will require accounting for the potential contribution of anisotropy on the structure / properties as this is expected to be different from that obtained by Close Die Forging. Engineering activities will require conducting material testing and/or sub-element testing and eventually Rig Testing for back-to-back comparison and to demonstrate equivalence with the current standard.

Full duration of the project: 4 years

- **Project Stage 1.- Review of requirements; identification of gaps.**

Duration: **3 months**

This activity shall focus on the compilation of the requirements from the OEMs. These will involve details with regards to the intended material structure as well as its expected mechanical properties. Additionally, a state of the art compilation shall be completed with regards to the existing modelling technology, Ring Rolling manufacturing capability etc. At this Project Stage a deliverable shall be issued with detailed definition of the specific needs; experimental, modelling etc. to take over the further Stages of the Project.

- **Project Stage 2.- Feasibility Study 1; Manufacturing at Subscale Level**

Duration: **15 months**

As part of this Project Stage, the manufacture of subscale components will be launched. This activity shall allow definition of a feasible geometry and process window to obtain the required material structure. The information generated hereby will additionally feed Modelling Activities. The Project at this Stage shall deliver a feasible geometry and process window and expected outcomes in terms of material structure to feed Project Stage 3. A critical review of the information generated at this very point shall feed a decision being taken with regards to whether the next Project Stage is launched.

- **Project Stage 3.- Feasibility Study 2; Manufacturing at Component Level**

Duration: **15 months**

As part of this Project Stage, the manufacture of representative shapes will be launched. Although details of the geometry cannot be fixed upfront, preliminary values are as follows: ID~800mm, Height ~115 thickness ~130mm. A number of manufacturing attempts will be completed to get a reasonable process map. A detailed evaluation of the resulting material structure together with a simple material characterisation shall be completed to drive a back-to-back comparison with that resulting from conventionally processed (Close Die Forging) IN718. The Project at this Stage shall deliver detailed information from the manufacturing trials and review and comparison against the initial predictions conducted in Stage 2 and the requirement per Stage 1. A critical review of those results shall support the definition of the detailed activities to be undertaken in Stage 4.

- **Project Stage 4.- Mechanical Testing Validation**

Duration: **15 months**

Data generated in Stage 3 shall allow a comparison to be made with previously existing data. Similarities or differences found between the material structure obtained by Ring Rolling vs. Close Die Forging and the preliminary mechanical data will feed and drive the definition of additional mechanical testing. The later will typically involve in addition to conventional material tests, completing sub-element or/and component testing by rig, covering component representative loading conditions.

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

- The applicant shall have a sound background on superalloys, their metallurgy and forming technologies; i.e. hot forming. This knowledge shall include both theoretical but experimental aspects.

- The applicant shall be able to design a process (tooling and associated equipment included) and have the capability to manufacture with the relevant process controls, representative ring geometries. This existing capability shall allow exploring the potential and limitations of a Ring Rolling alone forging route. This activity might require launching specific trials (Design Of Experiments) on representative rings so as to evaluate the cross effect of the relevant forging parameters in order to cover from simple up to profiled rings.

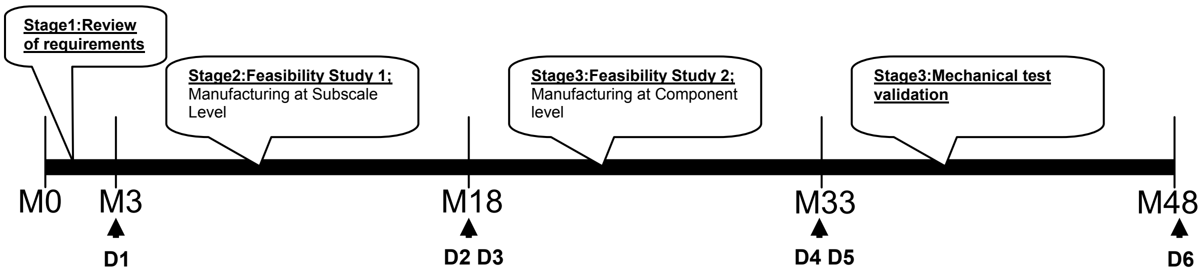
- The applicant shall already have the basic theoretical and experimental knowledge on material flow behaviour while forging. It is acknowledged some dedicated (lab scale or otherwise) testing might be needed to cover Ring Rolling.

- The applicant shall already have the capability to understand and predict material structure as a result of Forging Processes. Although some degree to experience and awareness on the specificities of Ring Rolling is preferred, it shall be able to develop and validate a material model to cover Ring Rolling alone and to incorporate it to a process modelling software tool.

- The applicant shall have or have access to laboratory testing facilities necessary for assessing the metallurgical condition and mechanical behaviour of IN718; either in the various intermediate stages while being rolled or the final product.

The later will typically involve the following tests being conducted covering different geometries and loading conditions: tensile and or compression, low cycle fatigue, crack propagation, fracture toughness etc.

47. Major deliverables and schedule



Deliverable	Title	Description (if applicable)	Due date
D1	Review of requirements and gaps identification report	Compilation of the requirements, of the state of the art analysis.	M0+3M
D2	Subscale components manufacturing		M18
D3	Geometry and process window report	Report specifying the feasible geometry and process window and expected outcomes in terms of material structure	M18
D4	Manufacturing trials at component level.		M33
D5	Trials detailed analysis report	Report summarising the resulting material structure , back to back comparison with close die forging and comparison with requirements in D1	M33
D6	Mechanical tests analysis report	Report summarising the mechanical tests performed and the analysed data.	M48

48. Topic value (€)

€ 1.0 M
[one million euro]

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

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.

49. Remarks

None.

Topic Description

CfP topic number	Title		
JTI-CS-2010-04-SAGE-04-001	**Development of low cost near conventional hot die forging process for γ-TiAl low pressure turbine blades**	**Start date**	*T0*
		End date	*T0 + 36M*

1. Topic Description

A first generation of geared turbofan engine (GTF) technology will be applied for the regional and narrow body market due to significant reductions in fuel consumption and noise compared to conventional turbo fan engines.

The purpose of the advanced geared turbofan demonstrator as part of the Sustainable and Green Engine (SAGE) platform is to further advance these technologies and to achieve a next step change in fuel burn reduction combined with an additional decrease in noise emission. Components and modules with new technologies are to be developed, implemented and validated through rig testing as required before integration into a donor engine and SAGE4 full engine demonstration. The successful validation of technologies for this aircraft engine concept will then facilitate the early introduction of innovative new products into the market, and significantly reduce further the environmental impact of air transport.

In order to answer the needs of the SAGE4 geared turbofan in terms of research, technological development and demonstration activities, it is planned to offer individual tasks to the industry, universities or any legal entity. Therefore, the present Call for Proposal supports the further development of novel lightweight γ-TiAl turbine blade material and the related casting and forging processes with a high optimization potential to allow alternative designs of environment - friendly aero-engine components.

The technical feasibility of forging γ-TiAl turbine blades by a near conventional hot die process has been demonstrated as fundamentally feasible. Near conventional forging processes, using conventional hydraulic forging presses and nickel alloy forging tools, have the potential to meet the ambitious cost targets. However the robustness of the process, e.g. the temperature control of the forging process and the post heat treatment parameters, need to be improved in order to meet the structural mechanical requirements.

The development and validation of a robust low cost production process for near conventional hot die forging of TNM γ-TiAl low pressure turbine blades in close co-operation with the aero engine manufacturer and demonstration of the technology readiness of the forging technology is required.

The partner for this topic shall perform the following activities:

- Evaluation of the influence of different billet material quality, geometry and dimensions on the forging process and heat treatment robustness;
- Evaluation of suitable forging tool designs, materials, manufacturing and repair processes in order to Increase the forging tool life time for robust forging parameters;
- Determination of deformation strains, strain velocities, preheat and post heat treatment temperatures to meet the structural mechanical requirements for TNM γ -TiAl low pressure turbine blades;
- Demonstration of technology readiness of the near conventional hot die forging process by producing a set of test hardware for SAGE4 demonstrator tests.

Task 1: Management

Organisation:

- The partner shall nominate a team dedicated to the project and should inform MTU AeroEngines 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 MTU AeroEngine), Technics & Quality.

Time Schedule & Workpackage Description:

- The partner is working to the agreed time-schedule & workpackage description.
- Both, the time-schedule and the workpackage description laid out in this Call shall be further detailed as required and agreed at the beginning of the project.

Progress Reporting & Reviews:

- Monthly 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.
- 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 in MTU AeroEngines facility.

General Requirements:

- The partner shall work to a certified standard process.

Task 2: Development of optimized billet material and designs

Development and validation of billet material quality and design for a robust near conventional hot die forging process for TNM γ -TiAl low pressure turbine blades.

Specification:

- Define criteria for billet material microstructures, geometry, dimensions, costs and weight.
- Define material, procurement and quality testing specification with the aero engine manufacturer.

Simulation:

- Forging process simulation for different billet material microstructures, geometries and dimensions.

Procurement:

- Benchmarking of different billet material production technologies and producers.
- Procure billet material for forging trials.

Forging trials:

- Forge hardware (pancakes and blades) from different billet geometries and dimensions.
- Evaluate dimensional and microanalytical and microstructural quality of the forgings and perform testing of mechanical properties.

Task 3: Development of forging tools for the near conventional hot die forging process

Development and validation of the most low cost forging die material, die design and manufacturing and repair technology for near conventional hot die forging of TNM γ -TiAl low pressure turbine blades.

Specification:

- Define criteria for forging tool materials, designs, lifetime, manufacturing and repair technologies.

Simulation:

- Forging process simulation for different forging tool materials and designs.

Manufacturing:

- Manufacturing and repair trials for different forging tool materials and designs.

Forging Trials:

- Evaluate the lifetime of different forging tool materials and designs, manufacturing as well as repair technologies.

Task 4: Development of robust near conventional hot die forging process parameter

Development and validation of the most robust near conventional hot die forging process parameters for the forging of TNM γ -TiAl low pressure turbine blades.

Specification:

- Define criteria for forging strains, strain rates and temperatures: minimum and maximum values, local distributions.

Simulation:

- Simulation of the forging process for different strains, strain rates and temperature distributions.

Forging Trials:

- Forging trials with different strains, strain rates and temperature distributions in order to validate the optimum forging parameters.

Task 5: Demonstration of technology readiness of the forging process

Method of manufacturing:

- Demonstrate an optimized and cost efficient robust near conventional hot die forging process for TNM γ-TiAl low pressure turbine blade production with minimum billet material input weight.
- Define the methods of manufacturing for all required production steps, adequate documentation system, according to all necessary specifications.

Forging of test hardware:

- Produce one set of forgings for an engine test.
- Quality testing of forgings to ensure that all properties are within specification limits.

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

- Specific isothermal direct heated upset forging equipment for the production of TNM γ - TiAl low pressure turbine blades.
- Hydraulic press with direct forging tool heating system, ram speed control and forging parameter monitoring system.
- Specific thermal barrier coating technology needed for the near conventional hot die TNM γ-TiAl forging process.
- Extensive experience in the area of near conventional hot die TNM γ-TiAl forging.
- Specific Heat treatment furnace which allow extreme small thermal treatment process windows (min. ± 5 °C).

- Certified supplier of MTU Aero Engines for forged and heat treated products. - Certification: ISO 9001, EN9100, EN ISO 14001, NADCAP heat treating certificate, NADCAP non destructive testing cerfificate. - Project management competence in accordance to IPMA standards.

3. Major deliverables and schedule

Deliverable	Title	Description	Due date
D1	Detailed Project Plan	schedule with milestones, technical specification of process and equipment	T0 + 1M
D2	Provision of optimized billet material	Specifications for billet microstructure, geometries, dimensional tolerances, weight	T0 + 12M
D3	Provision of optimized forging tools	Specifications for forging tool material, design, manufacturing and repair technologies	T0 + 12M
D4	Provision of optimized forging parameters	Specifications for forging strains, strain rates, temperatures	T0 + 18M
D5	Engine test hardware	One set of TNM γ-TiAl low pressure turbine forged parts for demonstrator engine test (SAGE4) and results of quality testing	T0 + 30M
D6	Method of manufacturing (MOM)	Specified detailed description of suppliers forging and heat treatment process parameters	T0 + 36M

4. Topic value (€)

650,000 €
[six 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

Topic Description

CfP topic number	Title		
JTI-CS-2010-04-SAGE-04-002	**Development of near net shape isothermal forging process for γ-TiAl low pressure turbine blades**	Start date	*T0*
		End date	*T0 + 36M*

1. Topic Description

A first generation of geared turbofan engine (GTF) technology will be applied for the regional and narrow body market due to significant reductions in fuel consumption and noise compared to conventional turbo fan engines.

The purpose of the advanced geared turbofan demonstrator as part of the Sustainable and Green Engine (SAGE) platform is to further advance these technologies and to achieve a next step change in fuel burn reduction combined with an additional decrease in noise emission. Components and modules with new technologies are to be developed, implemented and validated through rig testing as required before integration into a donor engine and SAGE4 full engine demonstration. The successful validation of technologies for this aircraft engine concept will then facilitate the early introduction of innovative new products into the market, and significantly reduce further the environmental impact of air transport.

In order to answer the needs of the SAGE4 geared turbofan in terms of research, technological development and demonstration activities, it is planned to offer individual tasks to the industry, universities or any legal entity. Therefore, the present Call for Proposal supports the further development of novel lightweight γ-TiAl turbine blade material and the related casting and forging processes with a high optimization potential to allow alternative designs of environment - friendly aero-engine components.

The technical feasibility of forging single γ-TiAl low pressure turbine blade preforms by a near neat shape isothermal forging process has been demonstrated as technical feasible. However the economical feasibility of the process, e.g. forging tooling costs and the forging cycle time for forging in an inert gas atmosphere, need to be improved in order to meet the cost targets.

The development and validation of an economical production process for near neat shape isothermal forging of TNM γ-TiAl low pressure turbine blades in close co-operation with the aero engine manufacturer and demonstration of the technology readiness of the forging technology is required.

The partner for this topic shall perform the following activities:

- Evaluation of the influence of different billet material quality, geometry and dimensions on the forging parts costs suitable for the isothermal forging process;
- Evaluation of advanced isothermal forging die materials in order to reduce tooling costs;
- Determination of deformation strains, strain rates, forging temperatures and post heat treatment temperatures to meet the structural mechanical requirements for TNM γ -TiAl low pressure turbine blades and cost targets for the forged perform.
- Demonstration of technology readiness of the near net shape isothermal forging process by producing a set of test hardware for SAGE4 demonstrator tests.

<u>Task 1: Management</u>

Organisation:

- The partner shall nominate a team dedicated to the project and should inform MTU AeroEngines 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 MTU AeroEngine), Technics & Quality.

Time Schedule & Workpackage Description:

- The partner is working to the agreed time-schedule & workpackage description.

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

Progress Reporting & Reviews:

- Monthly 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.
- 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 in MTU AeroEngines facility.

General Requirements:

- The partner shall work to a certified standard process.

Task 2: Development of optimized billet designs for the isothermal forging process

Development and validation of low weight billet material design for the near net shape isothermal forging of TNM γ-TiAl low pressure turbine blades.

Specification:

- Define criteria for billet material geometry, dimensions, weight and costs.
- Define procurement specification with the aero engine manufacturer.

Simulation:

- Forging process simulation for different billet geometries and dimensions.

Procurement:

- Procurement of billet material from different supply sources for forging trials.

Forging trials:

- Forge test hardware (pancakes and blades) from different billet geometries and dimensions.
- Evaluate dimensional and microanalytical and microstructural quality of the forgings and perform testing of mechanical properties.

Task 3: Evaluation of low cost isothermal forging tools

Evaluation of available forging die materials for forging TNM γ-TiAl low pressure turbine blades.

Specification:

- Define criteria for forging tool materials, designs and lifetime.

Simulation:

- Forging process simulation for different forging tool materials and designs.

Procurement:

- Procurement of forging tools representing different tool materials and designs.

Forging Trials:

- Evaluate the lifetime of different forging tool materials and designs for increase forging temperatures and forging strain rates.

Task 4: Development of low cost isothermal forging process parameters

Development and validation of the most low cost near net shape isothermal forging process parameters for the forging of TNM γ-TiAl low pressure turbine blades.

Specification:

- Define criteria for forging strains, strain rates and temperatures: minimum and maximum values and local distributions.

Simulation:

- Simulation of the forging process for different strains, strain rates and temperature distributions.

Forging Trials:

- Forging trials with different strains, strain rates and temperature distributions in order to validate the optimum forging parameters for decreased forging cycle times.

Task 5: Demonstration of technology readiness of the isothermal forging process

Method of manufacturing:

- Demonstrate an optimized and low cost near net shape isothermal forging process for TNM γ-TiAl low pressure turbine blade production with maximum cycle time and minimum forging tool costs.
- Define the methods of manufacturing for all required production steps, adequate documentation system, according to all necessary specifications.

Forging of test hardware:

- Produce one set of forgings for an engine test.
- Quality testing of forgings to ensure that all properties are within specification limits.

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

- Specific low cost isothermal forging tool design and direct tool heating system for near net shape forging of TNM γ - TiAl low pressure turbine blade preforms using a conventional hydraulic forging press.
- Forging press force capacity for isothermal forging technology for near net shape forging of TNM γ - TiAl low pressure turbine blade preforms.
- Experience in the area of near net shape isothermal forging of γ-TiAl components.
- Specific heat treatment furnace which allow extreme small thermal treatment process windows (min. ± 5 °C).
- Certified supplier of Aero Engine Manufacturers for forged and heat treated products.
- Certification: ISO 9001, EN9100, NADCAP heat treating certificate, NADCAP non destructive testing certificate.

3. Major deliverables and schedule

Deliverable	Title	Description	Due date
D1	Detailed Project Plan	schedule with milestones, technical specification of process and equipment	T0 + 1M
D2	Provision of optimized billet material	Specifications for billet geometries, dimensional tolerances, weight	T0 + 14M
D3	Provision of optimized forging tools	Specifications for forging tool material, design	T0 + 14M
D4	Provision of optimized forging parameters	Specifications for forging strains, strain rates, temperatures	T0 + 20M
D5	Engine test hardware	One set of TNM γ-TiAl low pressure turbine forged preforms for demonstrator engine test (SAGE4) and results of quality testing	T0 + 26M
D6	Method of manufacturing (MOM)	Specified detailed description of suppliers forging and heat treatment process parameters	T0 + 36M

4. Topic value (€)

600,000 €
[six hundred thousand euro]

This topic value is a maximum gross value for the work package. Awards between 50% and 75% of this value may be made by the Clean Sky Joint Undertaking.

5. Remarks

Topic Description

CfP topic number	Title		
JTI-CS-2010-04-SAGE-04-003	**Development and validation of an integrated methodology to establish future production concepts**	Start date	T0
		End date	T0 + 28M

1. Topic Description

A first generation of geared turbofan engine (GTF) technology has found its way into the regional and narrow body market due to significant reductions in fuel consumption and noise compared to conventional turbo fan engines.

The purpose of the advanced geared turbofan demonstrator as part of the Sustainable and Green Engine (SAGE) platform is to further advance these technologies and to achieve a next step change in fuel burn reduction combined with an additional decrease in noise emission. Components and modules with new technologies are to be developed, implemented and validated through rig testing as required before integration into a donor engine and SAGE4 full engine demonstration. The successful validation of technologies for this aircraft engine concept will then facilitate the early introduction of innovative new products into the market, and significantly reduce the environmental impact of air transport.

The new engine programs, highly focused on efficiency, require innovative approaches regarding materials, engineering and design of engine parts and engine modules. In order to fulfil increasing quality criteria, targets of manufacturing cost, adequate lead times and an efficient way of fabrication of those new engine parts and modules, the current production system has to be completely reviewed and restructured to keep sustainable advantage in competition.

Therefore, the present Call for Proposal supports the further development and validation of an

"Integrated methodology to establish future production concepts based on upcoming new engine programs"

At present MTU Aero Engines works at different areas on new and alternative production concepts, e.g. focused on product families such as blisk, discs, etc. as well as based on specific processes and technology developments. The development of productions concepts takes place at varying hierarchical levels and areas within the organisation. The gap to close within this work is to develop a generic methodology for the integrated development of future production concepts considering necessary requirements based on new engines components, the demands of the future market, existing division circumstances as well as new processes and technologies for manufacturing. Additionally, the generic, integrated methodology has to meet the superior production principles determined by the management.

The methodology to establish future production concepts has to fulfil the following requirements:

- It must represent a **robust** methodology to support the company with a sophisticated orientation for future production concepts even during changes of the general business framework, such as increasing/decreasing quantities, changing cost structures, alternative technologies, etc.

- It must deliver **sustainable** results as a base for the realisation of optimized production concepts at the company's plants

- It must be based on a **systematic and repeatable** procedure in order to be able to review the production concepts in specific period of times

- The methodology must be **applicable in an efficient way**, e.g. being supported by IT tools and a clear methodology proceeding

The partner has to validate the developed methodology for new production concepts based on a selected product family of new engine components/modules and has to work out a detailed production system including layout, logistic systems, integration of technologies, segmentation of the product spectrum, etc.

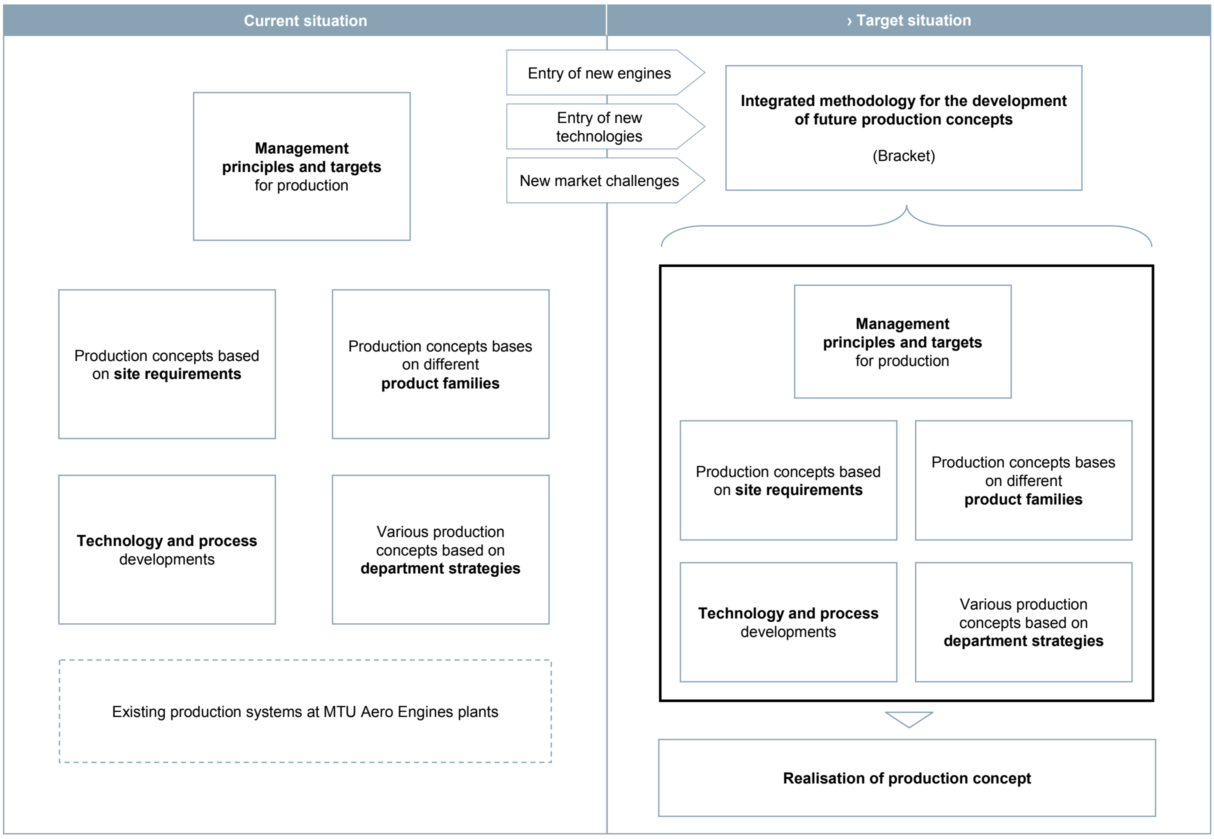


Figure 1: Current unstructured situation and target situation; Methodology as a "bracket" for the development of future production concepts for new efficient engine programs

As an overall result the project achieves an integrated methodology to develop and align the future production concept for new engine programs to meet the upcoming challenges within the aircraft engine business.

Based on the given targets, the partners work includes the following tasks:

Task 1: Management

Organisation:

- The partner shall nominate a team dedicated to the project and should inform MTU AeroEngines 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 MTU AeroEngine), Technics & Quality.

Time Schedule & Workpackage Description:

- The partner is working to the agreed time-schedule & workpackage description.
- Both, the time-schedule and the workpackage 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.

- 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 in MTU AeroEngines facility.

General Requirements:

- The partner shall work to a certified standard process.

Task 2: Definition of methodology approach

Within work package 1 the partner has to define in cooperation with MTU Aero Engines the general methodology approach. Therefore the partner identifies various approaches in order to achieve an integrated methodology for future production concepts and performs an evaluation of different approaches with the target to take decision for the best approach. The task includes the investigation of current methodologies within the research environment (e.g. universities, third party partners, etc.) as well as the adaptation to existing characteristics. Additionally, the partner has to determine the scope and the interactions of the methodology to similar topics.

Main targets:

- Identification of different approaches to establish a methodology for future production concepts
- Evaluation of different approaches and chose for one approach
- Definition of the methodology scope and interaction to similar topics

Task 3: Analysis current fields of production concept development

The partner analyses during work package 2 the current fields and activities regarding production concepts and strategies. The main task will be to collect and summarise actual activities within the different departments and areas which are involved in production concepts, strategies, technology developments, etc., for example future studies of product families, roadmap for technology developments, and expansion of site structure. The partner has to gather all information and processes with a relevant impact on future production concepts and has to establish a big picture of current activities and coherences. In a second step the partner specifies further details of the big picture and highlights main points for an integrated methodology to develop future production concepts. In addition to the gathering of current activities the partner has to identify main influencing factors for the methodology, e.g. product quantities, cost structures, quality issues, etc.

Main targets:

- Gathering information and processes regarding current activities in production concepts
- Creating a big picture of current activities and highlight coherences
- Definition of main points for the further development of a methodology
- Work out main influencing factors for an integrated methodology

Task 4: Development of an integrated methodology for future production concepts supported by IT/software tools

After definition of an approach and the knowledge about current activities in the field of production concepts the partner develops an integrated methodology in order to align the production concepts to future requirements. The methodology must follow the defined constraints of a robust, sustainable, repeatable and efficient way of working out an optimal production concept considering relevant impact factors such as quantities, technologies, manufacturing costs and quality aspects. The partner has to point out direct and indirect interactions (e.g. interactions between future technologies and the start of production of new product families) and has to come up with a generic production concept model. The model has to be verified regarding completeness and applicability within the special and complex environment of production processes. Additionally, the production concept model has to consider existing production principles determined by the management and the market.

For the further implementation of the methodology the partner has to create detailed functional specifications for supporting IT/software tools. If indicated the partner also has to develop parts of software supporting tools during the project phase in order to verify and proof algorithm and the applicability of software tools to support the methodology for the development of future production concepts.

Main targets:

- Development of a generic production concept model
- Adaptation of the methodology within a special and complex environment of production processes
- Considering superior production principles
- Detailed functional specifications of software tools in order to support the methodology
- Development of software tools to support parts of the methodology (pilot study development)

Task 5: Validation

After the finalisation of a generic production concept model in task 3, the methodology has to be verified based on a selected MTU AeroEngines specific case study. The partner has to design and validate a future production concept with the help of the developed methodology starting from a strategic perspective down to a detailed planning task of the production module including product segmentation, layout design, implementing an adapted logistic system, considering organisational and new technology issues, apply developed software tools, etc.

Focused on Key Performance Indicators and benchmarks the established production concept as a result of the integrated methodology has to demonstrate a fully working operating unit based on best practice standards including the complexity of manufacturing efficient engine parts and modules.

Main targets:

- Selection of a specific MTU AeroEngines case study in order to apply the generic methodology for a new production concept
- The partner starts from a strategic perspective down to a detailed production concept planning for the selected product family in order to verify the methodology
- Development of KPI's and benchmark figures to allow evaluating the developed production concept

Task 6: Summary

The partner has to gather all information, proceedings and results of the developed generic methodology as well as the validation of the model within comprehensive project documentation.

In addition, the partner has to document during the project all established tools and files and has to hand over the documentation including a short instruction to the documentation structure.

Main targets:

- Create and hand over comprehensive project documentation
- Documentation of all established tools and files during the project

Challenges

The production of aircraft engines parts and modules is a quite complicate and specific process. Focused on safety and quality issues of the product as well as a high level of production technology and difficult operations the manufacturing of engines components differs significantly from other production concepts and strategies. As a result the creation of future production concepts for an engine manufacturer is a highly important and complex issue. Additionally, the manufacturer operates in a turbulent supplier and customer market environment.

In order to respond timely to the current developments in the aircraft engine business and to stay in competition, an integrated methodology for future production concepts and strategies has to be established. After clear strategies regarding the development of production concepts, supported through the established methodology, a detailed roadmap for the following realisation phase to achieve new production concepts will be created.

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

Requirements for applicant

- Wide range of services from strategically concepts to detailed planning work and realisation of production/logistic systems
- Experience with the planning of production/logistic processes of different branches (aircraft, automotive, consumer, metal industry, etc.) in order to transfer knowledge from other branches
- Sophisticated knowledge of the specific production/logistic processes of aircraft engine components manufacturing
- Capability to use modern digital manufacturing methods (e.g. simulation) in the fields of complex production processes like aero engine manufacturing
- Knowledge and capability to operate research work in the environment of universities, research labs, etc. Connections or partners at universities are beneficial.
- Project references regarding the development of systematically methodologies and evidence of a general systematically approach at project work

Favourable

- Knowledge regarding MTU Aero Engines production and logistic processes, quality aspects, material flows, organisational structure, standards, competences and capacities
- Databases and information about workflows, procedures, technology processes, etc. within the general aircraft business
- Ability to operate the project in German as well as in English language
- The partner is located close to MTU Aero Engines Munich to ensure a quick information transfer and short respond time during the project
- Knowledge about existing IT/software tools in order to ensure an efficient way of integration new tools within the companies IT concept

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Detailed Project Plan	schedule with milestones, technical specification of methodology approach	T0 + 1M
D2	Workshop – Common main points	Workshop	T0 + 6M
D3	Result – Analysis current activities	Milestone 2	T0 + 8M
D4	Result – Development method	Milestone 3	T0 + 8M
D5	Result – Validation	Milestone 4	T0 + 22M
D6	Final report	Milestone 5	T0 + 28M

4. Topic value (€)

1,000,000 € **[one million euro]** This topic value is a maximum gross value for the work package. Awards between 50% and 75% of this value may be made by the Clean Sky Joint Undertaking.

5. Remarks

A detailed work plan and time schedule is being expected. A profound financial plan must be attached as well. The applicant must fulfil the above mentioned requirements.

Topic Description

CfP topic number	Title		
JTI-CS-2010-04-SAGE-04-004	**Development of low cost casting process for γ - TiAl billets**	Start date	*T0*
		End date	*T0 + 36M*

1. Topic Description

A first generation of geared turbofan engine (GTF) technology will be applied for the regional and narrow body market due to significant reductions in fuel consumption and noise compared to conventional turbo fan engines.

The purpose of the advanced geared turbofan demonstrator as part of the Sustainable and Green Engine (SAGE) platform is to further advance these technologies and to achieve a next step change in fuel burn reduction combined with an additional decrease in noise emission. Components and modules with new technologies are to be developed, implemented and validated through rig testing as required before integration into a donor engine and SAGE4 full engine demonstration. The successful validation of technologies for this aircraft engine concept will then facilitate the early introduction of innovative new products into the market, and significantly reduce further the environmental impact of air transport.

In order to answer the needs of the SAGE4 geared turbofan in terms of research, technological development and demonstration activities, it is planned to offer individual tasks to the industry, universities or any legal entity. Therefore, the present Call for Proposal supports the further development of novel lightweight γ-TiAl turbine blade material and the related casting and forging processes with a high optimization potential to allow alternative designs of environment - friendly aero-engine components.

The forging process of single TNM γ-TiAl low pressure turbine blades requires billet material produced by a casting process. Both, gravity casting or spin casting has been demonstrated as technical fundamentally feasible. For production readiness of the casting process, the material input weight has to be decreased and the yield rate has to be increased significantly to ensure the economical feasibility of the process.

The development and validation of an economical production process for TNM γ-TiAl billet material to be used for the forging process of TNM γ-TiAl low pressure turbine blades is required.

The partner for this topic Shall perform the following activities:

- Evaluation of different processes for the TNM γ-TiAl ingot material production processes and supply sources including recycling of the casting process revert material;

- Evaluation of different permanent mould materials, designs as well as manufacturing and repair technologies to increase the permanent mould life time and reduce casting process tooling costs;

- Determination of casting process methods and parameters: gravity or spin casting process, mould temperature, overheat temperature of the molten alloy, filling procedure, process cycle time;

- Demonstration of technology readiness of the billet casting process by producing a set of billets for forging test hardware for SAGE4 demonstrator tests.

<u>Task 1: Management</u>

Organisation:

- The partner shall nominate a team dedicated to the project and should inform MTU AeroEngines 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 MTU AeroEngine), Technics & Quality.

Time Schedule & Workpackage Description:

- The partner is working to the agreed time-schedule & workpackage description.

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

Progress Reporting & Reviews:

- Monthly 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.
- 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 in MTU AeroEngines facility.

General Requirements:

- The partner shall work to a certified standard process.

Task 2: Evaluation of ingot production processes for the billet casting process

Evaluation of TNM γ -TiAl ingot material from different supply sources and produced by different methods, e.g. plasma arc melting, vacuum arc remelting, combinations of both and the feasibility of recycling casting revert and scrap material.

Specification:

- Define criteria for ingot material chemical composition tolerances, shape, dimensions, weight and costs.
- Define procurement specification with the aero engine manufacturer.

Procurement:

- Procurement of ingot material from different supply sources and made by different melting methods for casting trials.

Casting Trials:

- Casting billets by gravity and spin casting from ingot material representing different ingot production technologies and suppliers.
- Evaluate microanalytical and microstructural quality of the cast billets.

Task 3: Development of permanent moulds technology for the billet casting process

Development of geometries and dimensions as well as evaluation of different materials, manufacturing and repair technologies for permanent moulds to be use for casting TNM γ -TiAl billet material.

Specification:

- Define criteria for permanent mould materials, designs, lifetime, manufacturing and repair technologies.

Procurement:

- Procurement of permanent moulds representing different mould materials, designs, manufacturing and repair technologies.

Casting Trials:

- Evaluate the lifetime of different permanent mould materials, designs, manufacturing and repair technologies.

Task 4: Development of low cost casting process parameters

Development and validation of casting methods and parameters for the most low cost casting process for billets used for the forging process of TNM γ -TiAl low pressure turbine blades.

Specification:

- Define criteria for castings methods and process parameters, e.g. temperatures of moulds and molten material, atmosphere, filling procedure, filling velocity and pressure, material input, yield rates, costs.

Simulation:

- Simulation of the casting process, e.g. gravity and spin casting process to ensure minimum material input, maximum yield rate and minimum operating costs.

Casting Trials:

- Evaluation of the influence of different melting processes for producing the molten alloy for the casting process, e.g. vacuum arc remelting, vacuum skull induction melting.
- Evaluation of different casting process parameters to develop an optimized casting of TNM γ -TiAl billets process.

Task 5: Demonstration of technology readiness for the casting of billets process

Method of manufacturing:

- Demonstrate an optimized and low cost casting process for billets suitable for to be used for forging TNM γ-TiAl low pressure turbine blades with maximum yield rate and minimum material input, tooling and operating costs.
- Define the methods of manufacturing for all required casting process steps, adequate documentation system, according to all necessary specifications.

Casting of billets for forging test hardware:

- Produce one set of billets for forging TNM γ-TiAl low pressure turbine blades for an engine test.
- Quality testing of billets to ensure that all properties are within specification limits.

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

- Spin casting equipment with a skull induction melting and vacuum arc remelting unit for casting TNM γ - TiAl billets.
- Extensive experience in the area of casting TNM γ - TiAl billets for to be used for the forging process of low pressure turbine blades.
- Certified supplier for cast products.
- Certification: ISO 9001, EN9100, EN ISO 14001.

3. Major deliverables and schedule

Deliverable	Title	Description	Due date
D1	Detailed Project Plan	schedule with milestones, technical specification of process and equipment	T0 + 1M
D2	Provision of optimized ingot material specifications	Material and procurement specifications for serial production of ingot material	T0 + 12M
D3	Provision of optimized permanent mould technology	Specifications for permanent mould material, design manufacturing and repair technologies	T0 + 12M
D4	Provision of optimized casting parameters	Specifications for casting temperatures, filling methods and velocities, cycle times	T0 + 24M
D5	Provision of Billets for forging engine test hardware	One set of TNM γ-TiAl bilets for forging low pressure turbine blades for demonstrator engine test (SAGE4) and results of quality testing	T0 + 24M
D6	Method of manufacturing (MOM)	Specified detailed description of suppliers casting of billets process parameters	T0 + 36M

4. Topic value (€)

550,000 € **[five 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

Clean Sky Joint Undertaking
JTI-CS-2010-4-SAGE-04-005

Topic Description

CfP topic number	Title		
JTI-CS-2010-04-SAGE-04-005	**Development & Manufacture of High Temperature <u>C</u>arbon <u>F</u>ibre <u>R</u>einforced <u>P</u>lastic (<u>CFRP</u>) Aero engine Parts for Continuous Use at Temperatures above 350°C**	Start date	*T0*
		End date	*T0 + 24M*

1. Topic Description

A first generation of geared turbofan engine (GTF) technology has found its way into the regional and narrow body market due to significant reductions in fuel consumption and noise compared to conventional turbo fan engines.

The purpose of the advanced geared turbofan demonstrator as part of the Sustainable and Green Engine (SAGE) platform is to further advance these technologies and to achieve a next step change in fuel burn reduction combined with an additional decrease in noise emission. Components and modules with new technologies are to be developed, implemented and validated through rig testing as required before integration into a donor engine and SAGE4 full engine demonstration. The successful validation of technologies for this aircraft engine concept will then facilitate the early introduction of innovative new products into the market, and significantly reduce the environmental impact of air transport.

In order to answer the needs of the SAGE4 geared turbofan in terms of research, technological development and demonstration activities, it is planned to offer individual tasks to the industry, universities or any legal entity. Therefore, the present Call for Proposal supports the further development of materials with a high optimization potential to allow alternate designs of environment-friendly aero-engine components.

Light weight composites can reduce the weight of aircrafts significantly. The composites used in airframes do not withstand aero engine temperatures. Special high temperature composites are necessary to withstand the elevated temperatures.

The objective is the development of a CFRP laminate for a high temperature application in an aero engine with a typical engine service life of several thousand hours. Standard CFRP suffers from oxidation and loss of strength with increasing temperatures. Thermal cycling additionally causes micro cracks in the matrix resin. The micro cracks can grow to severe delamination during the life cycle and damage the strength and environmental resistance. Standard CFRP composites are limited to a scope of 260 °C maximum temperature. The development of new resin blends allows a temperature scope > 350°C. A temperature > 350°C cope with the temperature requirements of the first stages of a high pressure compressor. Typical parts where CFRP is applicable are rotating air tubes and inner seal rings.

The development process for a high temperature CFRP starts with the composition of a fibre/matrix system with high oxidation resistance and low inner strains. Specific design rules for laminate thickness and fibre orientation should be developed with respect to the resin properties. In the following step the allowables in terms of temperature, stress and environmental resistance must be tested by certifiable test method.

Based on the evaluated data prototype engine parts must be build for component tests.

The application of CFRP parts can reduce component weight (by 25%-50%) and cost (by 15% to 20%).

Based on the given requirements, the partners work includes the following tasks:

<u>Task 1: Management</u>

Organisation:

• The partner shall nominate a team dedicated to the project and should inform MTU AeroEngines 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 MTU AeroEngine), Technics & Quality.

Time Schedule & Workpackage Description:

• The partner is working to the agreed time-schedule & workpackage description.

• Both, the time-schedule and the workpackage 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.

• 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 in MTU AeroEngines facility.

General Requirements:

• The partner shall work to a certified standard process.

Task 2: Test of fibre /resin combination at high temperature

• Definition of a high strength/ high temperature fibre / resin combination

• Manufacture of test specimen with optimized fibre resin combination

• Static strength test of un-aged and aged test specimen at room temperature and elevated temperature

• Test of environmental resistance against water, alcohol, fuel, oil, etc.

• Fire behaviour (toxic fumes, flammability)

Task 3: Aircraft Engine Part Prototype Manufacture

• Support of CFRP Engine Part Prototype design with respect to material requirements

• Manufacture of a engine part (e.g. inner seal ring, rotating covering tube) according to MTU standard drawing with final machining.

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

• Experience with high temperature Carbon Fibre Reinforced Composites.

• Capability to involve a certified material test institute for specimen tests.

• Capability of specimen and engine part manufacture.

• Capability of machining CFRP. A certifiable quality management system (e.g. ISO9001).

• Serial production of high temperature (> 350°C) resin composite parts.

• The partner should have the industrial capacity to further develop, optimise, certify and produce aero engine parts for serial production under commercial conditions.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Detailed Project Plan	schedule with milestones, technical specification of process and equipment	T0 + 1M
D2	Provision of material data at elevated temperature (20°C, 200 °C, 250°C)	Tension, bending, interlaminar shear, modulus (statistically sufficient number of test is 6 for a single temperature) and 2 different fibre orientations	T0 + 6M
D3	Provision of material data (aged material 250°C/1000h, 350°C/500 h)	Repetition of D2 tests with aged material	T0 + 12M
D4	Development of tooling for prototype part	Tooling ready for production tests	T0 + 12M
D5	Production tests/ quality demonstration	Tension test of test specimen taken from prototype parts (unaged/aged)	T0 + 18M
D6	Production of Prototype parts /quality assessment	8 with quality approve for rig /engine tests	T0 + 24M

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

A detailed work plan and time schedule is being expected. A profound financial plan must be attached as well. The applicant must fulfil the above mentioned requirements.

Topic Description

CfP topic number	Title		
JTI-CS-2010-04-SAGE-04-006	**Machining of highly stressed components: Development of Precise Electrochemical Machining (PECM) Simulation tool**	Start date	*T0*
		End date	*T0 + 36M*

1. Topic Description

A first generation of geared turbofan engine (GTF) technology has found its way into the regional and narrow body market due to significant reductions in fuel consumption and noise compared to conventional turbo fan engines.

The purpose of the advanced geared turbofan demonstrator as part of the Sustainable and Green Engine (SAGE) platform is to further advance these technologies and to achieve a next step change in fuel burn reduction combined with an additional decrease in noise emission. Components and modules with new technologies are to be developed, implemented and validated through rig testing as required before integration into a donor engine and SAGE4 full engine demonstration. The successful validation of technologies for this aircraft engine concept will then facilitate the early introduction of innovative new products into the market, and significantly reduce the environmental impact of air transport.

In order to answer the needs of the SAGE4 geared turbofan in terms of research, technological development and demonstration activities, it is planned to offer individual tasks to the industry, universities or any legal entity. Therefore, the present Call for Proposal supports the further development of manufacturing methods with a high optimization potential to allow alternate designs of environment-friendly aero-engine components, which can be machined by means of a non conventional method, namely precise electrochemical machining (PECM).

As the precise electrochemical machining (PECM) of engine parts, especially of rotating and life limited parts, is a very versatile process with a huge number of possible influences, a detailed knowledge of the process itself is inevitable to realize a stable and reliable manufacturing process.

Therefore, a detailed evaluation and simulation of the PECM process is necessary, including the surface and near surface conditions and the electrochemical behaviour during machining, aiming at a dynamic process simulation of the PECM process.

The main target of the project is the development and validation of a 3D mathematical process model of the PECM Process. The necessary steps to be taken are described in the following Tasks. As the topics of the Tasks are interconnected, we strongly encourage the partner to parallelize their work on the different Topics thoroughly to avoid double work.

<u>Task 1: Management</u>

Organisation:

– The partner shall nominate a team dedicated to the project and should inform MTU AeroEngines 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 MTU AeroEngine), Technics & Quality.

Time Schedule & Workpackage Description:

– The partner is working to the agreed time-schedule & workpackage description.

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

Progress Reporting & Reviews:

– Monthly one-pager and 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.

– 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 quarterly held in MTU AeroEngines facility.

General Requirements:

– The partner shall work to a certified standard process.

Task 2: Parameter Analysis

The partner shall carefully evaluate the interdependencies of significant machining parameters, relating to the following main topics:

– Identification of the significant and determining process parameters.

– Evaluation of the interdependencies of the previously identified parameters and provision of a mathematical model.

Typical parameters are, for example temperature, pressure and composition of the electrolyte but also the potential applied to the sample during machining, the resulting current flow and the sample geometry as well as the feed rate of the machine.

The partner should also consider using statistical methods, i.e. design of experiments (DoE) for the identification of significant parameters.

The partner shall submit their results to MTU AeroEngines for discussion and approval.

Task 3: Influence of Electrochemical and Physical Properties

The partner shall evaluate the electrochemical and physical processes during electrochemical machining and give a mathematical description of the relevant physical and chemical processes.

The partner shall focus their research on the following aspects:

– Near surface diffusion behaviour.

– Active / passive transitions at potentials more positive than the first transpassive potential.

– Evolution of gas (e.g. oxygen) during machining and its influence on the passivation behaviour.

– Local and overall current density distribution.

Further aspects may be added for evaluation by the partner if found relevant for modelling the machining process.

Especially the influence of the electrolyte flow on the process shall be taken into account by the partner, as it is a key aspect in electrochemical machining processes.

The partner shall develop a mathematical model resulting in a 3D simulation of the machining process, including the results from Task 2.

Based on further lab tests to be defined together with MTU AeroEngines, the partner shall validate the model in general. A comprehensive optimization is not necessary at this time. The final 3D simulation model shall be also capable of giving a theoretical material loss rate for an idealized base material system.

The results of this evaluation must be visualized and delivered to MTU AeroEngines by the partner in a data format that can be edited and run at MTU AeroEngines.

Task 4: Impact of Material Properties

The partner shall evaluate the interdependency of material characteristics and the previously identified parameters. This particularly includes the influence of:

– the microstructure, i.e. grain size, local crystallographic orientation and morphology,

– the local heterogeneities,

– the chemical properties, including global and local composition and – the physical properties on the local an global material removal rate.

Important materials are the new TiAl base materials, polycrystalline (e.g. IN 718, MAR-247, T64) and single crystalline (e.g. LEK94) nickel and titanium base materials.

Furthermore the electrochemical behaviour of these materials have to be evaluated under near-machining conditions, with special regards to the transpassive potential range and the transpassive-passive transition potential ranges.

The partner shall submit the documentation of the experiments and results to MTU AeroEngines for approval.

Task 5: Process Model Development and Optimization

The development of a mathematical process model and its validation by experiments are the key aspect of the project.

The partner shall combine the model and data from the previous tasks to build a comprehensive model for the 3D simulation of a running PECM process. This shall include the machining of typical 3D airfoil geometries of blades or vanes to be defined by MTU AeroEngines.

The final process model shall provide reliable information about the running PECM process and reduce the number of iteration cycles significantly below the current level.

Reliable means, that given a working system, a sample can be machined without any pre-testing from a known base metal (see Task 4). The sample surface shall have no major surface defects due to e.g. short circuit or inhomogeneous material removal afterwards.

The partner shall supply the model data itself, all test data concerning the model developed, a complete and detailed documentation of the 3D simulation process and the successful experiments to MTU AeroEngines for final approval.

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

- Extensive experience in the field of Precise Electrochemical Machining (PECM), including practical knowledge is mandatory.
- The partner must have a PECM-machine available for testing and optimization of the predicted model.
- Knowledge about physicochemical mechanism at surfaces, especially under transpassive conditions are mandatory.
- Master of German and English language is recommended.
- Extensive experience in simulation of electrochemical machining processes is mandatory.
- Experience in cooperation projects with industrial companies is necessary, ideally with the aerospace industry.
- The partner must have access to all necessary equipment and extensive knowledge to conduct a full chemical and physical base material characterisation, including a nanoscopic evaluation of base metals microstructure. This includes the following methods: REM, EDX, WDX and EBSD.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Detailed Project Plan	schedule with milestones, technical specification of simulation process	T0 + 1M
D2	Assessment of relevant parameters	see Task 2	T0 + 09M
D3	First theoretical Model approach	see Task 3	T0 + 18M
D4	Assessment of material properties influence	see Task 4	T0 + 24M
D5	3D simulation tool Validation	see Task 5	T0 + 36M

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.

5. Remarks

A detailed work plan and time schedule is being expected. A profound financial plan must be attached as well. The applicant must fulfil the above mentioned requirements.

Clean Sky - Smart Fixed Wing Aircraft

Identification	ITD - AREA - TOPIC	topics	VALUE	MAX FUND
JTI-CS-SFWA	**Clean Sky - Smart Fixed Wing Aircraft**	**5**	**2.105.000**	**1.578.750**
JTI-CS-SFWA-01	*Area01 – Smart Wing Technology*		**1.455.000**	
JTI-CS-2010-4-SFWA-01-013	Active Flow Control (AFC) techniques on trailing edge shroud for improved high lift configurations - design,		460.000	
JTI-CS-2010-4-SFWA-01-028	Structural tests on smart droop nose device with regards to aircraft level		745.000	
JTI-CS-2010-4-SFWA-01-029	Development, design and manufacture and test of AFC actuator controller wrt industrial purposes and		250.000	
JTI-CS-SFWA-02	*Area02 – New Configuration*		**650.000**	
JTI-CS-2010-4-SFWA-02-010	Innovative shield design and manufacturing		250.000	
JTI-CS-2010-4-SFWA-02-011	Impact test campaign		400.000	
JTI-CS-SFWA-03	*Area03 – Flight Demonstrators*			

European Commission
Research Directorates

Topic description

Topic Nr.	Title		
JTI-CS-2010-04-SFWA-01-013	**Active flow control (AFC) techniques on trailing edge shroud for improved high lift configurations – design, manufacture and tests**	**Start Date**	01.02.2011
		End Date	30.08.2013

1. Topic Description

Subject of this call for proposal is the design, manufacturing and experimental and numerical validation of a flow control technology applied to spoiler and flap of a 2D wing high lift configuration. The proof of concept of the design is the aerodynamic test at the applicant's facility at between Ma=0.10 and 0.20.

The objective is to delay the separation onset on the trailing edge (TE) of the flap by employing active flow control techniques which shall be applied to the spoiler and to the flap. Targeted is a high lift configuration with active flow control in a slat-less configuration with significant deployment angles for the flap and suitable drooped spoiler settings, in order to achieve separation delay on the flap by flow control means. This separation delay should be achievable with moderate flow control mass flows, in order to deliver a technology concept which might be applicable for more realistic configurations.

The structure of the spoiler has to enable spoiler droop. At the kink (result of the droop) and at the spoiler trailing edge active flow control actuators have to be integrated.

The model shall have the geometry of the DLR F15 2D high lift model with 0.6 m of chord and about 1 m of span (similar to DLR F15 model). In case such a model is not available, other high lift configurations may be used. In such case it has to be demonstrated that the results are suitable for ongoing work in the present SFWA work package.

The applicant has to develop a structural concept which minimizes the kink within the region of spoiler rotation. It is suggested that the aerodynamically smooth spoiler contour (in drooped conditions) is ensured by a smart structure concept. In addition to the smart structure concept, the applicant might investigate whether suction applied at the trailing edge of the spoiler could further minimize the effect of the kink onto the flow. The proof that the drooped spoiler contour is smooth enough for intended purpose is an essential part of the wind tunnel test.

The numerical simulations have to provide a proof of concept. The CFD tools have to predict the flow on the 2D reference configuration with deployed spoiler and flap, with and without flow control. These numerical studies have to be performed before the wind tunnel test is performed (to support the set up of the test programme) and after the 2D wind tunnel test to support the analysis of the measured data.

Also required is a CFD flow simulation of a swept configuration with flow control at spoiler and flap. A wind tunnel test of the swept configuration is not required.

The analysis of data for the 2D configuration (experimental, numerical data) and for the 2.5 D configuration (numerical data) must allow firm judgements on the success of the flow control strategy applied.
Specific and parameter settings for the CFD studies have to be jointly defined with the SFWA consortium.

It is expected, that existing knowledge on flow control actuation systems and hardware solutions will be used to optimize the output of the activities mentioned in this topic description.

The expected length of the proposal is assumed around 25 pages

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

- The applicant should have a sound R&T background in design, testing and demonstration of flow control techniques in wind tunnel facilities suitable for models of the size mentioned above, preferably on F15 geometry wind tunnel models.
- The applicant is able to integrate actuators in a wind tunnel model, can manufacture devices and testing of systems for flow control applications in wind tunnels. This includes the capability of initial functional tests at lab conditions.
- The applicant has sufficient expertise to perform CFD studies for configurations described above, the CFD methods of the applicant have been sufficiently validated for active flow control (including unsteady flow control operation) at start of the project to allow the intended simulations with sufficient reliability.
- The applicant has sufficient expertise on aerodynamic and structural topics, in order to make this a successful project (assuming the described flow control concept is suitable for low speed performance enhancement). The know-how on structures enables him, to develop a smart concept for a spoiler with functionalities as described above.

3. Major Deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D01	Report with recommendations for future work	Previous wind tunnel tests on 2D mid scale W/T model analysed	**30.04.2011**
D02	Concept report	Description of flow control strategy proposed by the applicant	**30.05.2011**
D03	Spoiler surface modelling	Modelling and simulation of surfaces for envisaged flow control applications	**30.06.2011**
D04	Concept report	Layout of smart structure concept for variable spoiler droops	**30.09.2011**
D05	Report with CFD recommendations for wind tunnel test.	Numerical studies with predictions of separational flow phenomena for 2D high lift configurations with and without flow control. Recommendations for wind tunnel test programme.	**01.10.2011**
D06	Design 2D mid scale tests	Design review of application of flow control means for drooped spoiler high lift configuration incl. Construction and manufacture requirements	**01.01.2012**
D07	Functionality test of structure concept	Lab test to validate the suitability of smart spoiler structure concept in view of flow control application.	**30.03.2012**
D08	Ready for mid scale 2D tests	Integration of flow control actuator techniques into spoiler and flap. Test readiness review.	**15.05.2012**
D09	2D wind tunnel tests conducted and analysed	Final wind tunnel tests with flow control on 2D model (F15 contour preferred) conducted in applicant facility and test data analysed. Detailed comparison of 2D test data with 2D numerical predictions.	**01.11.2012**

D10	Report with detailed analysis of CFD results for 2.5D set up	Numerical simulation of flow control applied to 2.5D set up with and without flow control for various parameters (spoiler settings, flap angles)	**30.05.2013**
D11	**Exploitation report for extension of flow control concept for a 2.5D set up**	Exploitation of test results for tested 2D set up and exploitation for simulated 2.5D set up, and outlook towards large scale tests.	15.07.2013
D12	**Final report.**	Final technical report about results and project closure.	30.08.2013

4. Topic value (€)

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

€ 460.000,--
[four hundred sixty thousand euro]

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

5. Estimated spend profile

2009	2010	2011	2012	2013	2014	2015
0	0	140	200	120	0	0

6. Remarks

Off-the-shelf flow control systems / actuators may be used for the tests. The costs for the flow control hardware (even if provided within cooperation with partners who have already knowledge on low speed flow control topics) have to be covered by the applicant.

Possible background knowledge and intellectual properties will be handled by individual implementation agreement, if it is needed.

Topic description

CfP Nr.	Title		
JTI-CS-2010-04-SFWA-01-028	**Tests of a smart droop nose structure of real aircraft size**	**Start Date**	01.01.2011
		End Date	31.03.2014

1. CfP Description

A smart leading edge device like a gapless smart droop nose device consists of a flexible outer skin structure and an actuation mechanism located inside of the leading edge to deflect the flexible skin structure of the leading edge.

Subject of this call for proposal is the test of large scale structural components for a smart droop nose wing leading edge device section of 2m resembling real aircraft size. Design requirements will be provided by SFWA partners where as the smart droop nose skin structure will be designed and manufactured by DLR. The test rig and actuation mechanism required for testing has to be provided by the applicant. Geometrical details, demands for deployment, the kinematic design and mechanical actuator performance will be provided at the start of the project by a SFWA partner. In the context of this call for proposal 'integrated' means that the skin structure developed by DLR in the JTI-SFWA will be integrated into a test rig additionally featuring driving kinematics provided by the applicant. It is demanded that the test rig, actuation mechanism and accompanying test equipment fulfil aircraft level requirements.

The work to be performed by the applicant spans the arc from integrated test rig concept development over detailed design, manufacturing and assembly to test conduction and data analysis. This includes the following:

- Overall concept development for the integrated test rig
- Detailed design of test rig consisting of a front spar with support including the driving mechanism
- Selection and provision of test equipment
- Manufacturing (or modification of an existing rig) and assembly
- Test conduction and data analysis

The rig test has to prove the concept of the smart droop nose structure. The integrated droop nose driving mechanism has to verify the structural concept of the droop nose device and to prove that the concept is suitable to be integrated in a real transport aircraft wing.
The test conduction has to be done by the applicant according to the test matrix requirements provided by SFWA partners.

In a design review process the capability of the driving kinematics, the structural test rig performance during operation and wing bending need to be demonstrated.

The surface quality of the droop nose has to be suitable for a laminar flow at cruise conditions. The test matrix will address the material properties of the smart droop nose device section and the surface quality of this delivered section in the deployed and re-attracted configuration. Furthermore, the effects of selected failure cases on the structural performance of the droop nose structure have to be performed. The description of an integration concept of this smart leading edge device towards verification in an aircraft scale structural ground test with full wing configuration has to be delivered.

Detailed test requirements:

The functionality of the rig with respect to structural performance and system integration has to be numerically proven through suitable simulation on aircraft level.
The test rig consists of a front spar like box beam to mount the composite leading edge structure provided by DLR and the driving kinematics and actuators (see Figure 1). The adjustable box beam allows simulating realistic wing bending following a given wing bending curve. Force actuators will be employed to generate the beam bending. General dimensions should be about 3.5 m length with a cross section in accordance to the considered wing section for the smart leading edge.
The test rig must allow mounting and testing of several smart droop nose structures and a general emulation of droop nose specific external loads such as wing bending.
Maintaining the desired contour shape fidelity and surface quality are of utmost importance including a smooth dynamic motion during deployment for relevant deployment angles. The test matrix will be derived from these requirements.
Structural tests have to be performed for the 1g, 2g and 2.5g cases, which are reflected through different wing bending settings. In case of the 1g and 2g cases, it has to be proven that the droop nose structure maintains structural integrity during deployment. Furthermore selected failure investigations for driving kinematics for these two settings have to be performed in accordance to industrial requirements. The 2.5g case has to be conducted with the droop nose already deployed, where structural integrity has to be proven and selected failure has also to be investigated with respect to industrial requirements.
During all structural tests the overall droop nose shape and the surface waviness have to be measured with optical equipment with a deflection resolution of 1/1000mm. This resolution is required in order to analyze the surface waviness computed from local structural deflection measurements.
At selected load attachment substructures strain gauge measurements have to be performed with respect to industrial requirements for accuracy. Structural strains up to 1% have to be measured, and structurally integrated strain sensors can not be considered.
Furthermore, the droop nose skin deflection must be measured along the entire nose perimeter at two discrete spanwise locations. Here, contour shape without and during deployment have to be measured as well as the surface waviness analyzed.
In order to evaluate how the mechanical actuation system can be integrated into the structures of the droop nose skin and the test rig itself, strain measurements at its structural components have to be conducted before and during the droop nose test. Measurements have to be analyzed with respect of how well the integration can be performed and how the actuation system effects the structure to be performed. Undesired loading in the components of the mechanical actuation system has to be identified and minimized. The effect of selected failure cases of the driving kinematics to the smart droop nose structure and front spar need to be measured and analyzed.

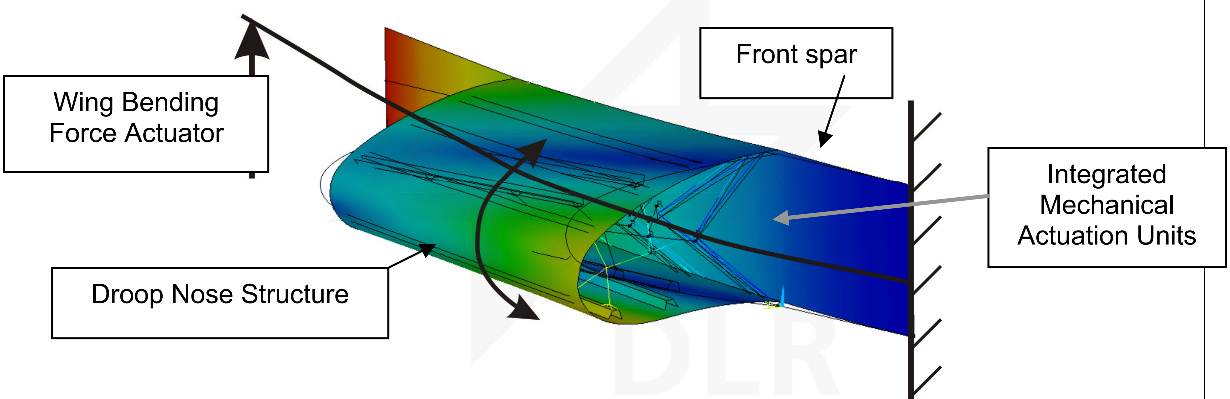


Figure 1 Schematic illustration of integrated test of smart droop nose structure under wing bending

The expected length of the proposal is assumed around 25pages.

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

- The applicant has the capability to manufacture a smart leading device structure including structural wing leading edge box for integration of smart leading edge section of a device component
- The applicant should have a sound research background and understanding of industry needs, expertise in leading edge structures and system integration for low speed flow control on industrial high lift configurations.
- The applicant has the capability on access on test rig facilities on component level.
- The applicant has to have manufacturing capabilities of the set-up / adaptation of test environments on component level with respect to dimensions on aircraft level, system support capabilities and equipment necessary for structural and system integration measurements and investigations.
- The applicant has expertise in the numerical simulations of large scale high lift test beds.
- The applicant has to provide support for integration & operation in super-coordinate tests.
- All numerical or experimental tools for a detailed design process must be available at the applicant.

3. Major Deliverables and schedule

Del. Ref. Nr.	Title	Description (if applicable)	Due date
D01	Initial Concept Developed	Initial concept definition developed and report of structure device including kinematics and test objectives for morphing performed.	**30.06.2011**
M01	Test Definition Review	Detailed concept description of test matrix and conceptual test bed, mechanical actuation system and structural components design.	**31.12.2011**
D02	Detailed Design Report	Detailed design for integration for smart droop nose device including test rig, driving and structural system	**31.03.2013**
M02	Test Rig Integrated and Operational	Integration for smart droop nose device including test rig, driving and structural system, first operational test performed	**30.09.2013**
M03	Integrated Tests Performed	Structural tests (loads cases and tests for selected failure investigation) conducted with respect to different device configurations and system integration needs.	**31.12.2013**
D03	Preliminary Analysis of Test Results	Test results pre-analysed and presented	**31.12.2013**
D04	Reporting, Exploitation and Project Closure	Final data analysis, final technical reporting and exploitation towards aircraft integration and certification issues (e.g. bird strike, anti-icing, etc.)	**31.03.2014**

4. Value of CfP workpackage

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

€ 745.000,--
[seven hundred forty five thousand euro]

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

5. Estimated spend profile

2009	2010	2011	2012	2013	2014	2015
0	0	150	250	300	45	0

6. Remarks

Possible background knowledge and intellectual properties will be handled by individual implementation agreement, if it is needed.

Topic description

CfP Nr.	Title		
JTI-CS-2010-04-SFWA-01-029	**Development and test of a closed loop control system prototype for active flow control at the wing's trailing edge**		01.05.2011
		End Date	31.05.2012

1. CfP Description

A complete Closed Loop Control System (CLC-System) for fluidic active flow control (AFC) actuation at the wing's trailing edge has to be designed together with the necessary controller unit. A prototype of the integrated controller unit has to be developed and tested. The unit should include the CLC-system, all necessary sensor links, the sensor signal analysis function, the control functions and the transducer electronics This industrial-type controller prototype has to be miniaturized for being integrated into the fluidic actuator or near to it in a real aircraft wing. The Aircraft and actuation architecture will be provided by the respective ITD members

The CLC-System will handle a single flow control actuator, but needs to link to an ensemble of flow control actuators and the aircraft's flight control system. In this sense it has to be implemented in the overall active flow control system architecture of the aircraft. Possible application of the flow control function may be to wing trailing edge devices for high lift applications or on the wing body for high speed applications.

Support to aircraft system architecture concepts and integration of the actuator system is expected from the applicant.

The controller should be designed allowing the actuator to meet its performance requirements in terms of mass flow and fluid pressure of the actuating flow, dimensionless mass flux rate, frequency, velocity of the pulsed jet flow and required surface topology with respect to aircraft level targets. The typical frequency range is between 15 Hz to 300 Hz for pulsed jet actuation and up to 1500 Hz for synthetic jet actuation. The design should be suitable for both applications and different transducer principle. Besides monitoring the AFC system, the CLC-System shall monitor the performance and aerodynamic behaviour of the active flow control.

The flow controller performance should be designed for full-scale aircraft requirements with respect to material selection, power consumption and on-board communication interfaces. Certification of the prototype is not requested but should be possible. Industrial grade components can be considered where appropriate.

Proof of the concept and system performance of the complete actuation system will to be demonstrated on a SFWA wind tunnel model. Results shall be analyzed and the CLC-System should be optimized with regards to aero-system requirements. This laboratory environment is considered sufficient for demonstrating the required flow control capabilities.

The final description of the integrated controller should report technical data, but consider also system and economic issues like operability, reliability, maintenance and respective costs for aircraft level integration.

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

- A calibrated laboratory environmental test unit has to be available
- Sound industrial background in design and manufacturing of controllers and control systems, esp. closed loop control of actuators is mandatory
- A sound research background and understanding of industry needs, expertise in closed loop control and system performance for low speed flow control on industrial high-lift configurations.
- Experience in manufacturing and demonstrating industrial mock-ups on aircraft level
- System support capabilities and equipment necessary for system and aerodynamic measurements / investigations.

3. Major Deliverables and schedule

Del. Ref. Nr.	Title	Description (if applicable)	Due date
D01	Pre-design analysis and concept Report	Description of conceptual design.	**01.06.2011**
D02	Components	Construction and manufacturing of mock-up of system needs allocated.	**01.07.2011**
D03	Manufacturing	All components available for integration. (TRR)	**01.09.2011**
D04	**Testing**	Tests conducted with regards to design variations and system performances needs and pre-analysed.	15.11.2011
D05	**Technical report**	Final test data analysis and final reporting	15.12.2011
D06	**Delivery prototype**	Design and manufacture of downsized principle prototype for ground tests. Delivery of prototype. Documentation.	01.02.2012
D07	**Final technical report**	Final test data analysis and final reporting	15.05.2012

4. Value of CfP work package

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

€ 250.000,--

[two]

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

5. Estimated spend profile [Euro]

2009	2010	2011	2012	2013	2014	2015
0	0	120	130	0	0	0

6. Remarks

Possible background knowledge and intellectual properties will be handled via an individual implementation agreement, if needed.

Topic Description Sheet

CfP Nr.	Title		
JTI-CS-2010-04-SFWA-02-010	**Design and manufacturing of innovative shield**	Start Date	01.02.2011
		End Date	28.02.2013

1. CfP Description

Subject of this call for proposal is the design and manufacturing of shielding material test articles for the purpose of assessment of their ballistic performance and their A/C integration constraints.

The here-above mentioned shielding are intended to be used as “stand alone” amour in the aircraft for the protection of critical components against high-velocity shrapnels in case of engine burst.

The concerned technologies and designs shall present the following features:

- Protection against penetration of metallic projectile whose kinetic energies are between 1kJ and 10kJ at a velocity of approximately 500 m/s,
- Lightweight innovative features suitable for similar ballistic or shielding applications
- Reasonable confidence in the fulfilment of A/C integration constraints. Both temperature conditions "hot" and “normal” (i.e. uncontrolled, environmental temperature) should be addressed by the sets of materials, even if each material taken individually may address only one of the environmental conditions,

Non exhaustive or limitative acceptable candidates of types of materials are composite based on high-performance fibres (such as Aramid, Polyethylene, Polybenzoxazole, Carbon nano tubes reinforced fibers).

The shielding test articles that will be assessed have overall dimensions of approximately 500 mm x 500 mm.

The work package should cover up to five (with a minimum of four) different types of innovative shielding materials and should include the following contributions for each of the shielding material type:

- general design of shielding test article
- sizing of test articles in collaboration with other work packages
- detailed design of test articles
- manufacturing and supply of test articles
- support for the assessment of material types versus A/C integration functions

With the delivery of the innovative shielding material test samples fife test samples of a standard metallic reference material shall be provided for experimental comparison.

A total of 160 samples (including optional work package) should be supplied for several (a maximum of four) series of impact performance assessments.
Depending of materials, up to 10% of the samples should be delivered in aged / degraded conditions considering a standard environmental condition test that will be selected by the consortium.

The Proposal should identify a list of types of proposed appropriate materials, a general description, as well as their expected and/or known performance versus highlighted features.

Impact test data obtained in other work packages will be shared to the selected applicant.

The work package may be divided in several sub-work packages for assessing each considered material, particularly in the case where a consortium of several material suppliers applies to this Call for Proposal.
Proposals made by such consortium are particularly welcome.

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

- The applicant should have proven experience of supplying composite product to aeronautical field
- The applicant should have a sound industrial background in the supply and/or development and/or manufacture of shielding products for high velocity projectiles
- The applicant should have experience in the management of environmental conditions/ageing tests

3. Major Deliverables and schedule

Del. Ref. Nr.	Title	Description (if applicable)	Due date
.A-01	Shield materials types description report	Description of the materials that are proposed to be assessed including their expected lightweight performance against impact and the identification of proven material features that could substantiate the performance versus specified A/C constraints	**28.02.2011**
.A-02	Initial Sample summary list table	Initial version of a table identifying all shield material test articles retained for assessment and, at least, associated thickness features	**31.03.2011**
A-03	Test article definition reports See remark (1)	For each sets of test sample supplies, report including definition dossier of the test articles including drawing (if applicable)	**05.2011 to 06.2012**
A-04	Sets of test articles See remark (1)	Test articles supply (including shipping) with manufacturing quality certificates	**09.2011 to 09.2012**
A-05	Environmental test report	Report of the environmental/aged conditions tests related to the concerned test articles.	**31.10.2012**

(1) These deliverables will be split in several deliverables which will be noted as -a, -b,-c,-d, depending on the number of series for impact performance assessments.

4. Value of CfP workpackage

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

€ 250.000,--

[two hundred fifty thousand euro]

Any proposal with a budget larger that the amount shown here-below will be automatically declared ineligible and will not participate in the evaluation.
Please note that VAT is not applicable in the frame of the *CleanSky* program

5. Estimated spend profile

2010	2011	2012	2013	2014	2015
0	120	120	10	0	0

6. Remarks

Possible background knowledge and intellectual properties will be handled via an individual implementation agreement, if needed.

Topic Description Sheet

CfP Nr.	Title		
JTI-CS-2010-04-SFWA-02-011	**Impact Tests Campaign**	Start Date	01.02.2011
		End Date	28.02.2013

6. CfP Description

1.1. Introduction.

An impact test campaign is proposed to characterize different types of materials that may be suitable for "stand- alone" protections against small fragments from uncontained engine rotor failure. This event need to be considered to fulfill aircraft certification and safety requirements in innovative aircraft configurations like those considered within Clean Sky SFWA initiative.

1.2. Scope of the work.

The test campaign consists in a set of impacts under controlled conditions to evaluate shield material performances for protecting aircraft areas from small fragments impacts. The objective of the campaign is to determine ballistic limits of high performance materials with a reduced number of shots.

The test campaign will be developed in two consecutive phases.

Phase 1. Baseline impacts for shield ranking performance.

Test conditions will be fixed by the consortium by means of a Test Specification Note. Some sensitive information may be released only at a later date to the successful applicants. Typically, it will be tested:

- Four / five shields materials.
- Three types of impactors.
- One velocity per impactor.
- Five repetitions of every impact condition to achieve statistical confidence.

Phase 2. Impacts for shield optimization and parametric variations.

Based on Phase 1 results, the consortium will extended the Test Specification Note in order to study specific impact conditions. Some sensitive information may be released only at a later date to the successful applicants. Typically it may include:

- Effect of thickness in shield performance.
- Effect of impact obliquity angle.
- Shield evaluation under degraded conditions.
- Effect of shield boundary conditions.
- Residual protection to impact.
- Exploration of higher velocities and energies up to installation limits.

The total number of tests of this CfP are 160 shots.
Detailed information may be released only at a later date to the CfP successful applicants.

1.3. Requirements.

The selected laboratory must be able of:

- Manufacturing metallic impactors within consortium requirements.
- Calibrating gun velocities and impactor attitudes for proper impacts.
- Adapting the lab facilities for mounting shields in frames within consortium requirements: shields specimens will be provided by the consortium. Typical laminates sizes will be approximately 350 x 350 mm.
- Performing the tests campaign under controlled conditions: facilities must be able of shooting impactors of 25 mm frontal maximum size, up to 8 kJ and 600 m/s for Phase 1, and higher velocity levels for Phase 2. Maximum “obliquity” angle (angle between projectile trajectory and normal to target surface): 60°.
- Recording results and perform a technical evaluation of them.
- Load cells and strain gauges capabilities in a limited number of cases (10 % to 15 % of shots).
- Adaption of test installation (frame structure) for performing shield boundary conditions modifications.

1.4. Required results.

- Specimen evaluation before and after the tests (weight, photos, C-SCAN for damage extension).
- High velocity camera system for recording tests.
- Projectile velocity measurements before the impact, within tolerances marked by the consortium.
- If shield perforation, residual velocity, within tolerances marked by the consortium.
- Maximum shield deformation during impact.
- Impact force time history -resultant acting on frame structure-.
- Shield performance evaluation based on tests results.

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

- Proved experience in ballistic tests of high performance materials: military and/or aeronautical fields.
- Experimental facilities adapted for high velocity impacts: projectile manufacturing, specimen frame attachment and gun installations.
- Ballistic laboratory with proved experience at impact tests under aeronautical quality requirements.
- Gun installation able of shooting fragments of 25 mm maximum size at 600 m/s under controlled conditions.
- High accuracy systems for monitoring the impact tests: redundant velocity measurements, high speed video recording system, shield performance evaluation.
- Knowledge of composite materials suitable for shield performance.

8. Major deliverables and schedule

Del. Ref. Nr.	Title	Description (if applicable)	Due date
01	Presentation	Phase 1 progress report of Hybrid Armour impact tests.	**31.06.2011**
02	**Technical Report, video recordings and measurements**	Technical Note of Hybrid Armour Phase 1 impact tests.	**31.12.2011**
03	Presentation	Phase 2 progress report of Hybrid Armour impact tests.	**30.06.2012**
04	**Technical Report, video recordings and measurements**	Technical Note of Hybrid Armour Phase 1 impact tests.	**31.12.2012**
05	**Technical Report, video recordings and measurements**	Technical Note of Hybrid Armour impact tests campaign. Compilation document and conclusions.	**31.12.2012**

9. Value of CfP workpackage

The total value of biddings for this task should not exceed:

€ 400.000,--
[four hundred forty thousand euro]

- Any proposal with a budget larger that the amount shown will be automatically declared ineligible and will not participate in the evaluation.
- Please note that VAT is not applicable in the frame of the *CleanSky* program.

10. Estimated spend profile (k€)

2010	2011	2012	2013	2014	2015
0	200	180	20	0	0

11. Remarks

- The meetings for the impact testing activity monitoring will be held either in France, UK, and/or Spain, but preferably in Getafe.
- Impact tests should be done using maximum communalities for all shields to optimize subsidiary costs and speed up testing for the whole set of specimens.
- Possible background knowledge and intellectual properties will be handled via an individual implementation agreement, if needed.

Clean Sky - Systems for Green Operations

Identification	ITD - AREA - TOPIC	topics	VALUE	MAX FUND
JTI-CS-SGO	**Clean Sky - Systems for Green Operations**	**4**	**2.750.000**	**2.062.500**
JTI-CS-SGO-01	*Area-01 - Definition of Aircraft Solutions and explotation strategies*			
JTI-CS-SGO-02	*Area-02 - Management of Aircraft Energy*		**2.250.000**	
JTI-CS-2010-4-SGO-02-014	Construction of evaluation Power Modules (10) to a given design		250.000	
JTI-CS-2010-4-SGO-02-030	Test rig for endurance and reliabilty trials applied on TRL growth of high power Starter / Generators		2.000.000	
JTI-CS-SGO-03	*Area-03 - Management of Trajectory and Mission*		**500.000**	
JTI-CS-2010-4-SGO-03-009	Propfan equipped aircraft noise model		350.000	
JTI-CS-2010-4-SGO-03-010	High speed numerical integration techniques for precise prediction		150.000	
JTI-CS-SGO-04	*Area-04 - Aircraft Demonstrators*			
JTI-CS-SGO-05	*Area-05 - Aircraft-level assessment and exploitation*			

Clean Sky Joint Undertaking
JTI-CS-2010-4-SGO-02-014

Topic description

CfP Nbr	Title		
JTI-CS-2010--SGO-02-014	**Construction of Power Modules with Specific Design for Technology Validation**	**End date**	December 2012
		Start date	Jan 2011

1. Background

This activity within WP2.3.1 of SGO is concerned with the design, fabrication and evaluation of planar, or sandwich, module technologies for a high-temperature power electronics module. The work package consortium will deliver a liquid-cooled, 10kW Silicon Carbide-based power converter with a 4-leg topology. A non-hermetic technology is anticipated with a nominal ambient temperature range of -60°C to +200°C. Planar/sandwich packages have no bond wires, can be cooled from both sides delivering improved thermal performance and can be optimised to give exceptionally low parasitic inductance. Although potentially attractive, the assembly of such structures has historically proved complex and costly, involving a large number of piece parts and assembly processes. Key targets of the work therefore include techniques to reduce the cost and complexity of both the substrate and assembly process. The consortium is seeking a partner who can contribute to our targets as detailed below.

2. Scope of work

1) Design study:

Prepare a fully justified mechanical and thermal design for the planar module assembly process and provide predictions of in-service life under prospective in-service conditions.

2) Technologies for planar module substrate fabrication:

Establish rapid prototyping and volume manufacturing technologies to realise contact features and interconnect posts on DBC (Direct Bond Copper) or AMB (Active Metal Bonding) substrates. Target minimum feature size is 0.3 mm x 0.3 mm with a height of at least 0.5 mm. Materials, co-planarity and compliance to suit the chosen assembly process based on design study 1) and in service requirements.

3) Cost-effective manufacturing route:

Establish a manufacturing process, employing diffusion soldering, to assemble planar modules using the substrates developed in 1) and a minimum of additional piece parts and processes. The maximum allowable assembly temperature is 300°C.

3. Type of work

1) Design study:

A mixture of thermal and mechanical simulation will be required to establish the feasibility of the proposed substrate and module assembly. Application of physics of failure models will be required to assess end of life under prospective in-service conditions.

2) Technologies for sandwich substrate fabrication:

Investigate alternatives to substrate etch processes including (for example) electroplating and Direct Metal Laser Sintering (DMLS) to realise features for top contacts and interconnect posts. A significant challenge here will be maintenance of co-planarity of the layered assembly so controlled compliance is expected to be essential to ensure reproducible assembly.

2) Cost-effective manufacturing route:

Establish a low-temperature diffusion soldering process, to achieve thin, well filled joints, with a carefully controlled bond-line thickness at bonding temperatures below 300°C. Develop a manufacturing process employing diffusion soldering that can be applied to assemble the planar module with the minimum of process operations and piece parts.

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

The successful partner will have expertise and capability in rapid prototyping, electroforming and/or other additive processes applicable to the electronics industry. Experience in the application of thermal and mechanical co-design is essential as is knowledge of physics-of-failure-based reliability design. The partner will be skilled in the application of diffusion soldering and encapsulation to power electronic devices and modules. The partner will include a power module manufacturer equipped and resourced to provide the type and number of modules required for programme evaluation. Finally, the partner will be able to demonstrate an established track record in working with industry and academia on power module technologies for aerospace applications.

5. Major Deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Detailed substrate and process design	Fully justified design including mechanical, thermal and life models	April 2011
D2	Substrate technology delivered	Samples of substrates to agreed specification available. The specification will be generated as part of technical project meetings.	September 2011
D3	Assembly technology delivered	Samples of assembled planar modules available	December 2011
D4	Prototypes	Planar modules for 10 converter assemblies delivered	September 2012

6. Topic value (€)

The **maximum value** for this topic is **250,000 €**
[two hundred fifty thousand euro]

7. Remarks

Clean Sky Joint Undertaking
JTI-CS-2010-4-SGO-02-030

Topic description

CfP Nbr	Title		
JTI-CS-2010-4-SGO-02-030	**Test rig for endurance and reliability trials applied on TRL growth of high power Starter / Generators**	**End date**	01.09.2014
		Start date	01.10.2011

1. Background

The purpose of this Call for Proposal (CfP) is to design a specific test rig dedicated to endurance, reliability and health monitoring of high power rotating starter-generator for aeronautical applications. This type of equipment combining simulation of engine starting (from zero speed) and electrical generation is required by new architectures for Large aircraft studied in the frame of Cleansky programme.

The interest and the need of this specific test rig is to give more confidence in the equipment design in terms of reliability at equipment level, to demonstrate maturity level and to provide a more predictable maintenance concept.

Today, such test rigs have already been developed for static equipment. They are able to combine accelerated stress with defined environmental constraints. The current test benches available to test rotating machines can only be used to electrically, mechanically and thermally characterize the equipment.
The new test rig shall allow to monitor and to record various mechanical, electrical and thermal parameters over a long period of time at the appropriate rate and therefore to evaluate their evolution during endurance test sequences. For this last purpose, it is aimed to reach flexibility in the operating mode in order to easily modify the test sequences.
The method allowing achieving the objectives of endurance and reliability evaluation are included in this study along with the development and the delivery of a demonstrator of the related test rig.

2. Scope of work

The purpose of this CfP is to develop a new test bench using innovative concept, allowing new test configurations. This cannot be achievable by adapting an existing rig.

This test rig shall be designed in order to be more friendly regarding environment. In this way, low noise during operation, electrical re-injection on the supplying network (reversibility of electrical interfaces) and high level of efficiency are required. The choice of the type of cooling will take into account these drivers.
The test rig shall include all components allowing to comply with the objective. The perimeter of the supply is not limited to the motor, frame, gearbox, control system and cooling accessories, it will incorporate also all electrical supply from Industrial network to the motor, the complete measurement channels (i.e. sensors, torque meter, bay, data storage, data treatment, displays…) and the loads.
An attention will be paid on energy re-injection on the industrial network in the case where equipment under test is operating in motor mode.

A low level of pollution (acoustic and chemical) is requested.
The test rig will be installed in a room which is not part of the CfP. The dimensions of the test room are 5.5m length, 3.5m width, 2.8m height. The loads can be installed in a separate area. They are rated at 300 kW under either 115V AC tri-phased or 230 V AC tri-phased (frequency range : 350 Hz – 800 Hz).
In order to avoid presence of technicians in the test room during normal test operation, the bay(s) including monitoring, control and record will be localized nearby the room in which the drive motor is installed. The test rig shall be designed to withstand the relevant industrial standards. The CE marking is requested.

From drivers provided herein, the applicant shall analyze the possible domains to be explored and shall submit a methodology to test, to record and to evaluate the equipment characteristics.

The mechanical operating ranges (at the drive) are
Speed: 0 to 24000rpm

- Equipment under test operating in generating mode : 350kW (from 12000 rpm to 24000 rpm)
- Equipment under test operating in motor mode : Torque : 0 – 400 Nm (from 0 to 6000 rpm)
200 – 400 Nm (from 6000 rpm to 12000 rpm)

This test rig will not be designed to perform vibration tests and thermal environmental tests. The mechanical and thermal constraints onto the tested equipment will be those produced by its own operating conditions. It will be operated at ambient (0-40°C) and sea level.

The accuracy of the measurement will be defined during the methodology definition phase and will be obviously relevant with the measurement strategy and the monitored parameters.

Depending on the type of cooling, the interfaces with the test room will be clearly defined in the proposal. The losses to be taken into account will be those dissipated by the rig itself and the equipment under test as well.

Furthermore, the test rig shall be able to drive in such a way that tested rotating machines could be operated in starting mode then in generating mode without any interruption of the test sequence.

Unless in disagreement with methodology definition phase conclusions, a set of around 80 sensors can be envisaged through thermal, electrical and mechanical areas.
The system shall be able to select appropriate recorded data to follow in real-time evolution of parameters and display them.

Following main functions and features shall be considered:

1) Definition of methodology
    - The inputs will comprise technical equipment requirement, environmental constraints and expected figures of reliability to be reached.
    - The type of tests to be performed by the test rig will fully match to the new application of high power starter-generator.
    - Different flight phases will be simulated.
    - The health monitoring of electrical, mechanical and thermal parameters will allow to evaluate the aging and to predict the maintenance on specific components / or equipment.
2) Studies of the test rig.
    - Different test rig configurations will be proposed in accordance with the conclusions of the methodology phase described above.
    - Selection of the test rig considering the performances / objectives and related costs.
3) Development of the test rig.
    - Manufacture and installation at CfP topic manager premises localized near Paris /France.
    - Appropriate documentation as Users Manual and Maintenance
    - Training on operation and maintenance

3. Type of work

This topic will consist in the design, the development and the manufacturing of a test bench to perform endurance tests for high-speed rotating machines as well as the proposal of methodologies to perform the relevant tests.

Planning and deliveries
The activities of this study and development shall be limited to 36 months time period.
A kick-off meeting, a progress meeting and a final meeting will be scheduled with the topic manager.
This project is split into following tasks proposed to the applicant activities:

At **T0 on 01.10.2011**
Kick Off Review of high level requirements at topic manager premises
Task 1 – Definition of methodology : (T0+9M)
Review of the methodology phase results and selection of the one(s) which will be designed in the next phase
Task 2 - Test rig studies : (T0+18M)
Review of the design phase results and selection of the one(s) which will be implemented.
Task 3 – Test rig Development – Phase 1 : (T0+30M)
Manufacture of the selected bench(es).
Task 4 – Test rig Development – Phase 2: (T0+36M)
Installation of the test bench(es) in the facilities of SGO member. Acceptance test report to validate the bench.
Technical training from applicant to SGO member in order to allow SGO member to operate and maintain the test bench(es) autonomously.

Progress report will be requested every two months

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

For this study, the applicant shall satisfy following criteria:
- Strong experience in designing endurance rotating test benches suitable for aeronautical parameters
- Capability to translate autonomously high level requirements to measurable and recordable criteria and to propose innovative approach through a smart methodology.
- ISO qualification for the design and manufacturing of industrial test benches.
- Experience in monitoring and analyzing heath management sensors and parameters
- Knowledge of RTCA-DO-160 standard and aeronautic environmental requirements is an advantage to appreciate the functional envelope of the equipment to be tested.
- Insurance shall be provided to manage this work in time without delay for study and development phases.

5. Major Deliverables and schedule

Deliverable	Title		Due date
D1	- Report on proposed Methodologies - Selection of the most relevant options		June 2012
D2	- Design description and datasheet of test bench. - Preliminary Drawings		March 2013
D3	- Manufacturing of the selected test benches		March 2014
D4	- Installation of the test bench(es) at the topic manager facilities, - Acceptance test report of test bench(es) - Training on operation and maintenance - User's manual		Sept 2014

6. Topic value (€)

The maximum value for this topic is 2,000,000 €.
(Two millions Euro)
(VAT not applicable)

7. Remarks

Only if applicable.

Clean Sky Joint Undertaking
JTI-CS-2010-4-SGO-03-009

Topic description

CfP Nbr	Title		
JTI-CS-2010-4-SGO-03-009	**Turboprop and propfan equipped aircrafts noise emissions model**	**Start date**	01.02.2011
		End date	01.06.2013

1. Background

The Clean Sky project, Systems for Green Operations ITD, is looking for a supplier of an advanced computerized numerical model for noise emissions of turboprop and propfan equipped aircrafts, to become a partner of the consortium.

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

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

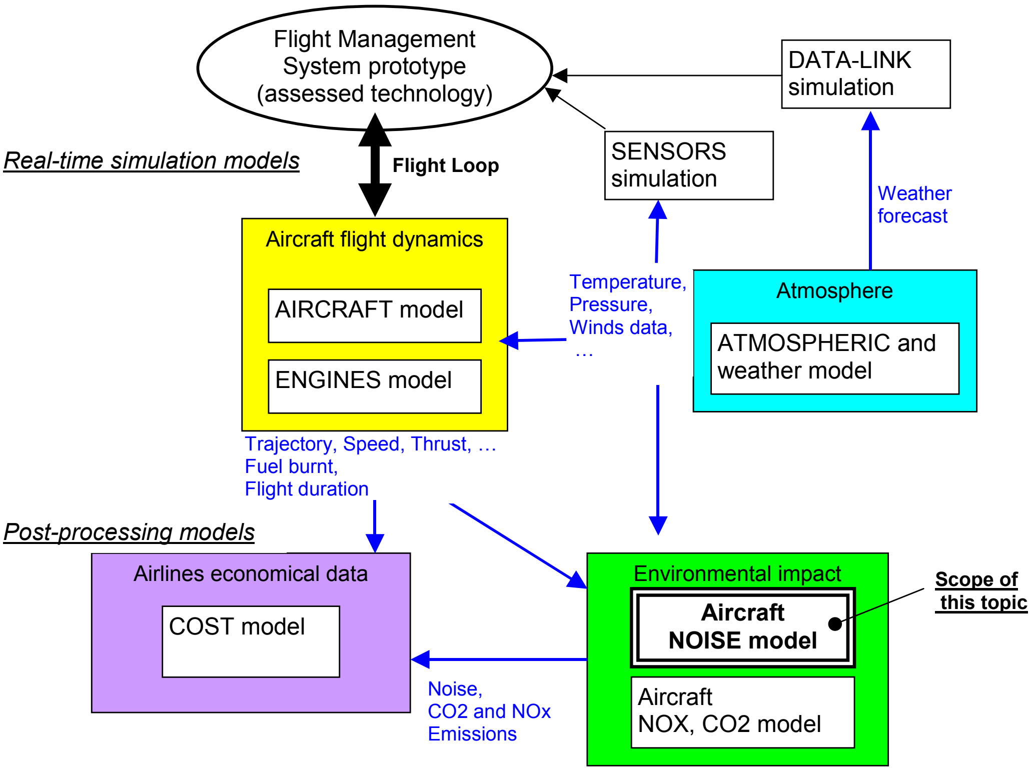
The System for Green Operations research consortium of CleanSky aims to demonstrate substantial reductions of environmental impacts in civil commercial mainline, regional aircraft and business jet domains.

The Management of Trajectory and Mission (MTM) branch of the Systems for Green Operations research consortium aims at developing technologies to reduce chemical emissions (CO_2 and NO_x) and Noise. One of the main field of research considered by MTM to reach these objectives is to optimize in-flight 4D trajectories, including the overall missions profiles, through mathematical optimisation.

Once an optimum trajectory will be found, it will be evaluated against current state of the art route. Simulations will be performed with emissions and noise models to assess the improvement of environmental performance achieved by the trajectory of the aircraft. Since the technologies and systems developed for trajectory and mission optimisation need to be inserted in the overall economical models of the airlines, which influence these operators choices, the operational “cost” of trajectory will also be assessed.

Implementation of these optimisations is foreseen either on-board, in an avionics computer, or on ground, using computing tools in a laboratory or in an airline operations centre. The activities of MTM will bring implementation prototypes of these technologies to avionics systems demonstration platforms.

Target demonstration platform description



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Context of use

Assessment of environmental performance achieved by the aircraft trajectory needs to be based on a working knowledge of how the aircraft contribute to noise and gas pollutant emissions. This knowledge will be used as mathematical physical models to compute each of these pollutions for a given 4D trajectory:

amount of noise perceived by the population surrounding an airport,

amount of carbon dioxide produced,

amount of nitrogen oxides produced,

amount of persistent water vapour released in the high atmosphere (to assess the formation of condensation trails)

These models will support the following MTM activities:

- Design better trajectories to reduce noise and gas pollutant emissions,
- Assess the performance of technology developed for green missions and trajectories,
- Enhance the representativeness of the simulations used for this assessment,
- Provide airborne systems to perform trajectory and mission optimisation based on that knowledge.

This topic looks after the computerized numerical model of the noise emissions for aircrafts powered by turboprop and propfan engines.

- '*Turboprop engines*' considered are the aircraft engines that use a gas turbine to drive an external propeller.

- '*Propfan engines*' considered are the modified turbofan engines also known as unducted fan (or ultra-high bypass engines, or open rotor jet engines), designed to reduce fuel consumption.

As the Systems for Green Operations ITD already uses the FAA's Integrated Noise Model (INM) and ECAC doc.29 (3rd edition) aircraft models, the computerized numerical model supplier shall bring significant improvements from these reference models.

2. Scope of work

Description of work

The consortium wishes to enter into partnership with a supplier able to design the noise emission model, or adapt and enhance an existing one, responding to the following general requirements.

Phase 1 – noise emission model

The new partner will first perform the following activities concerning the noise emission model:

- Make an inventory of existing methods or european research programs to modelise turboprop and in particular propfan engines, for potential re-use;
- Define the detailed technical specification (use cases, driving parameters, inputs/outputs of the model, technical requirements) in cooperation with the topic manager;
- Design and develop, or adapt, the numerical model;
- Identify reference aircraft trajectory tests cases and tests means to validate the model;
- Perform the tests of the model;
- Provide evidence of model pertinence consisting in comparison of estimated emissions against reference test data files;
- Deliver the numerical model with its associated documentation;
- Provide post delivery support of the model (see Support below).

Note that in Phase 1, the noise propagation and perceived noise at ground level are *not* in the scope of this topic.

Validation of model pertinence is a major driver. Therefore, the new partner shall propose a validation strategy according to the engine type:

- For turboprop engine, evidence of assessment against experimental data shall be provided.
- For propfan (open rotor) engine, as there is no commercial aircraft equipped with this kind of engine yet, theorical evidence that demonstrate the model representativeness is required.

Phase 2 – integration with propfan engine model and noise propagation tool

Then, the new partner will integrate this noise emission model with other components provided by the CleanSky SGO ITD:

- a propfan engine behaviour and performance model (giving thrust, torque, rotor speed, fuel flow, and engine temperatures according to thrust command and atmospheric conditions), in order to compute noise emissions of this type of engine;
- a noise propagation tool, in order to compute the perceived noise at a given point location on the ground (see below 'Main use cases and expected performance')

Interface and specifications of these components will be discussed with the topic manager as the detailed technical specification of the noise emissions model will be in progress.

-

Phase 3 – upgrade of noise propagation tool

Finally, the new partner will upgrade the noise propagation tool provided by the CleanSky SGO ITD:

- Analyse the impact on the noise propagation tool of specific noise propagation physical

phenomena from turboprop and propfan engine
- Adapt the noise propagation tool accordingly;
- Perform the tests of the upgraded propagation tool with the turboprop and propfan noise model;
- Deliver the upgraded noise propagation tool with its associated documentation;
- Provide post delivery support of the tool.

Technical requirements and constraints

The general technical requirements for the the computerized numerical noise model are:

Content

For given aircraft type and aircraft trajectory, the model shall compute airframe and engine noise emission around the aircraft.

The model shall encompass different aircrafts types powered by turboprop and propfan engines:

- various airframes types, configurations and geometries,
- various engine types, behaviour and thrust settings.

Input data

The noise emission model shall take into account the following data inputs:

- Choice of aircraft and engine type
- Atmospheric conditions around the airport (according to position): static air temperature, pressure, wind, humidity, …
- Aircraft trajectory along time: aircraft position (latitude, longitude, altitude), aircraft attitude (roll, pitch, heading), aircraft speed (true airspeed, ground speed),
- Aircraft configuration along time: landing gear and flaps configuration.
- Aircraft engine state along time: thrust level, …

Those data will be provided as a flight profile segment along time.

The resolutions, time samples or volumes required for these data are to be defined.

Output data

The output of the noise emission model shall be the perceived (spreading across the audible spectrum) noise emission hemisphere around the aircraft, with a decomposition per frequency.

The content and the format of the required noise emission data around the aircraft will be defined during the technical specification phase of the model.

The resolutions, time samples or volumes required for these data are to be defined.

Main use cases and expected performance

This model is used for off-line computation along aircraft trajectory segments. These aircraft flight segments will be take-off or approach/landing phases near airports, at altitudes lower than 15.000 feet above ground level, and of a duration of less than an hour.

The model requested by this topic shall provide the noise emission hemisphere around the aircraft in order to be connected to a distinct noise propagation tool which will compute the perceived noise at a given point location on the ground, and in the end will produce the noise metrics (typically those produced by INM v7.0: EPNL, SEL, …). *This noise propagation tool is not in the scope of the Phase 1 of this topic*.

Two main kinds of computation use cases are required (descriptions below implicitly include the contribution of noise propagation tool to clarify the general purpose of each use case):

(UC1) Assessment function in a fast-time closed-loop simulation

- The noise model is used in a fast-time 'batch' mode connected to an engineering simulation environment that will sequentially compute numerous trajectories in various conditions to analyze the sensitiveness and robustness of the prototypes.
- Computation of noise is performed in a few (typically 4 to 10) discrete locations around an airport. These locations depend on the airport.
- The required response time for the computation is a few seconds per trajectory segment.

(UC2) Off-line post-processing tool for overall assessment

- The noise model is used for off-line assessment of noise generated by trajectories flown by a pilot on a simulator.
- Noise computation is performed as a noise map around the airport, and loudness versus time can be extracted on each specified point of the map.
- A visualisation tool of the noise map around the aircraft along time is provided for interactive use.
- Capability is provided to export these noise maps as data files.
- The response time for the computation is expected to last less than the actual flight duration.

Implementation requirements

The model is expected to:

- be delivered as a software package running on Microsoft Windows XP Operating System preferably;
- run on a current generation PC, and share processing ressources with other applications;
- accept inputs and provide outputs through an API DLL and through a remote network access protocol.

Support

The model and the tool will be delivered to Clean Sky ITD SGO members for integration in their analysis suite.

The partner organization shall have the capability to maintain the model and the tool – i.e. to further adapt, optimize, and produce updated versions.

Several updated versions of the model and the tool will be developped during the timeframe of the topic (see §5. Major deliverables and schedule) to allow problems fix and evolutions.

3. Type of work

Development of a computerized numerical model for noise emissions of turboprop and propfan equipped aircrafts.

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

The candidate organization shall have recognized experience in numerical modelling of:

- noise produced by aircrafts engines and airframe,
- behavior and performance of turboprop and propfan engines.

The answer to this call for proposal must include a detailed technical description of the solution with the associated evidence of the expertise and pre-existing know how.

1. Major Deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
Phase 1	*Noise emission model*		
D0	Inventory of existing methods and models of turboprop and propfan engines.	Inventory of existing methods or european research programs to modelise turboprop and in particular propfan engines. Access and property right issues shall be analysed.	01.03.2011
D1	Model Technical Specification (TS)	Model detailed requirements and interface specifications document. This document shall include the description of the interface of the model with other tools and sources of data. The content of this document is defined and agreed in cooperation with the topic manager or his appointed representative, through technical workshops.	01.05.2011
D2	Model Definition and Justification Document (DJD)	Description and rationale for the chosen architecture of implementation, and analysis of compliance with requirements. Justifications or evidence that demonstrate the model representativeness shall be provided in this document.	01.07.2011
D3	Validation Test Plan (VTP)	Description of tests cases and tests means to validate the model. This test plan shall include the acceptance tests (see ATR deliverable below) to perform at the topic manager request.	01.07.2011
D4	Validation Test Report (VTR), Reference tests data files	Description of tests results and conclusions. This deliverable will be accepted through an acceptance review led by the topic manager.	01.10.2011
D5	Numerical model software delivery (V1): • Software executable for Windows (on DVD-ROM or CD-ROM) • Software version description document (VDD) • User Manual document (UM) • (if required) Update of previous documents : TS, DJD, VTP, VTR	1st release of the model. This deliverable will be accepted through an acceptance review led by the topic manager.	**Major milestone:** **01.01.2012**
D6	Acceptance Test Report (ATR-V1)	Description of the tests performed at the topic manager facility, their results and conclusions. This deliverable will be accepted through an acceptance review led by the topic manager.	01.02.2012
D7	Problem report and model modification request document (PRD)	Compilation and analysis of problem reports and modification requests agreed in cooperation with the topic manager or his appointed representative.	01.03.2012

Deliverable	Title	Description (if applicable)	Due date
D8	Numerical model software delivery (V2): • Software executable for Windows (on DVD-ROM or CD-ROM) • Software version description document (VDD) • User Manual document (UM) • (if required) Update of previous documents : TS, DJD, VTP, VTR	Release of a model update for problem fixes or evolutions.	01.05.2012
D9	Final Acceptance Test Report (ATR-V2)	Description of the tests performed at the topic manager facility, their results and conclusions. This deliverable will be accepted through an acceptance review led by the topic manager.	01.06.2012
D10	Numerical model software delivery (V3): • Software executable for Windows (on DVD-ROM or CD-ROM) • Software version description document (VDD) • User Manual document (UM) • (if required) Update of previous documents : TS, DJD, VTP, VTR, ATR	Release of a model update for problem fixes or evolutions.	01.06.2013 at the latest
Phase 2	*Integration with propfan engine model and noise propagation tool*		
D11	Propfan engine model integration report	Description of tests performed with the noise model and the propfan engine model (provided by the CleanSky ITD), their results and conclusions.	01.01.2012
D12	Noise propagation tool integration report	Description of tests performed with the noise model and the noise propagation tool (provided by the CleanSky ITD), their results and conclusions.	01.01.2012
Phase 3	*Upgrade of noise propagation tool*		
D13	Noise propagation tool upgrade analysis report.	Analysis of the noise propagation tool required upgrades to adapt it to turboprop and propfan specificities.	01.03.2012
D14	Noise propagation tool upgrade -Technical Specification (TS)	Detailed requirements and interface specifications document. The content of this document is defined and agreed in cooperation with the topic manager or his appointed representative, through technical workshops.	01.05.2012
D15	Noise propagation tool upgrade -Model Definition and Justification Document (DJD)	Description and rationale for the chosen architecture of implementation, and analysis of compliance with requirements.	01.07.2012

Deliverable	Title	Description (if applicable)	Due date
D16	Noise propagation tool upgrade -Validation Test Plan (VTP)	Description of tests cases and tests means to validate the model. This test plan shall include the acceptance tests (see ATR deliverable below) to perform at the topic manager request.	01.08.2012
D17	Noise propagation tool upgrade -Validation Test Report (VTR), Reference tests data files	Description of tests results and conclusions. This deliverable will be accepted through an acceptance review led by the topic manager.	01.09.2012
D18	Noise propagation tool upgrade software delivery: • Software executable for Windows (on DVD-ROM or CD-ROM) • Software version description document (VDD) • User Manual document (UM) • (if required) Update of previous documents : TS, DJD, VTP, VTR	This deliverable will be accepted through an acceptance review led by the topic manager.	01.10.2012
D19	Acceptance Test Report (ATR-V1)	Description of the tests performed at the topic manager facility, their results and conclusions. This deliverable will be accepted through an acceptance review led by the topic manager.	01.11.2012

6. Topic value (€)

The total value of this work package shall not exceed:

350,000.--€

[three hundred fifty thousand euro]

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

7. Remarks

Reporting

Progress reports will be established by the following elements:

- Description of activities performed
- Specification and development steps achieved
- Numerical simulation / test results technical reports
- Status of the next deliverables and review milestones

Meeting and review policy

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

Clean Sky Joint Undertaking
JTI-CS-2010-4-SGO-03-010

Topic description

CfP Nbr	Title		
JTI-CS-2010-4-SGO-03-010	**High speed numerical integration toolbox for precise prediction**	**Start date**	01.02.2011
		End date	01.02.2012

1. Background

The Clean Sky project, Systems for Green Operations ITD, is looking for a supplier of a software toolbox enabling to design real-time and high-speed trajectory software integrators package for aircraft avionics to become a partner of the consortium.

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

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

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

The Management of Trajectory and Mission (MTM) branch of the Systems for Green Operations research consortium aims at developing technologies to reduce chemical emissions (CO_2 and NO_x) and Noise. One of the main field of research considered by MTM to reach these objectives is to optimize in-flight 4D trajectories, including the overall missions profiles, through mathematical optimisation.

Once an optimum trajectory will be found, it will be evaluated against current state of the art trajectory for the selected route. Simulations will be performed with emissions and noise models to assess the improvement of environmental performance achieved by the trajectory of the aircraft. Since the technologies and systems developed for trajectory and mission optimisation need to be inserted in the overall economical models of the airlines, which influence these operators choices, the operational “cost” of trajectory will also be assessed.

Implementation of these optimisations is foreseen either on-board, in an avionics computer, or on ground, using computing tools in a laboratory or in an airline operations centre. The activities of MTM will bring implementation prototypes of these technologies to avionics systems demonstration platforms.

Theoretical context

Optimal control technique establish a general theory to the minimization of a performance index and the satisfaction of constraints whether initial, intermediate or final.

The general setting of offline trajectory optimization or on board guidance function is one of a two point boundary value optimal control problem. Indeed initial conditions are either a given state or the current estimated state of the vehicle by the navigation function, final conditions are also partially fixed (position conditions), and generally there are intermediate constraints to be satisfied (mixed position / velocity conditions and/or constraints derived from them). Then the two point boundary value problem occurs during the process of finding the guidance command, and solving for that the differential equations of the flight dynamics under the various constraints, and minimizing at the same time an optimization criterion (time of flight or propellant consumption minimization for instance).

No explicit solutions generally exist for solving the two point boundary value problem (only for very simplified dynamics such a solution may exist).

Note that the trajectory optimisation problem itself is out of the scope of this topic.

Aimed applications

The numerical integration of aircraft trajectory which is the purpose of this topic will be used either in an aircraft trajectory optimiser, or in a computation service for a flight management system (trajectory and predictions).

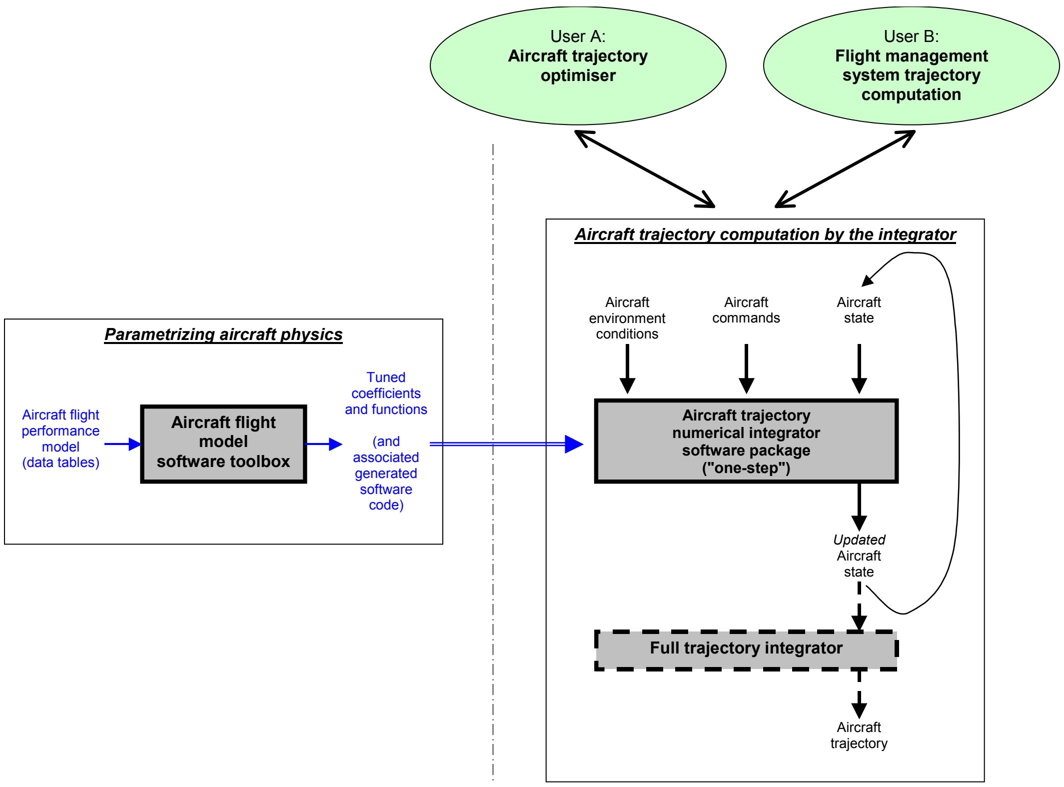
Both use cases require integration techniques to compute the aircraft state according to a model of its flight performance (aircraft dynamics, engine power, …). Only numerical techniques are sought for.

As trajectory optimisation technologies aimed by the ITD may be implemented aboard the aircraft, embedded in avionics systems, the aimed integrator software package shall enable high-speed real-time computation with limited resources.

The looked after technique to be used to implement the integrator shall be a neural network (but no "auto-adaptative" or "auto-learning" capabilities are required).

2. Scope of work

Components and expected benefits definitions



The aimed end-product of this topic is an ***aircraft trajectory numerical integrator software package*** enabling to numerically solve flight dynamics equations and compute aircraft state according to commands and current conditions. This software package is intended to be used as a building block for real-time trajectory optimiser prototypes. Therefore, this software package computation response time is a major issue.

The design of this software package requires an ***aircraft flight model software toolbox***, which use as input an aircraft performance model and that will produce as output the tuned coefficients, elementary functions, generated source code, or other parameters to implement the integrator efficiently.

3 kinds of benefits from the numerical integration technique shall be assessed on the *aircraft trajectory numerical integrator software package*:

- high-speed computation efficiency (main goal of the topic): response time for given resources to compute a full aircraft trajectory

- accuracy: the integrator shall not produce inaccuracies greater than those of the aircraft performance source data.
- usage domain: the integrator shall be able to achieve reduced but predictable accuracy when performing the computation outside the boundaries of the source data tables.

Description of work

The consortium wishes to enter into partnership with a supplier able to design a solution to the following general requirements.

The new partner will:

- Make the full definition of the detailed theoretical problem to solve, by collecting the topic manager needs and inputs (typical trajectory computations, available aircraft dynamics models, …).
- Specify the detailed numerical integration method, *using neural networks*, to perform the computation of the aircraft trajectory.
- Define the demonstration plan to exhibit the benefits of the technique. Identify the reference technique(s), the reference aircraft trajectory test case(s). Define a reference computing platform to assess the real-time performance of the implementations.
- Specify, design and develop *aircraft flight model software toolbox*.
- Specify, design and develop the *aircraft trajectory numerical integrator software package*, which is an implementation of the defined integration method.
- Perform the planned tests (numerical integrations) on the toolbox and the package, and provide the results.
- Assess computing resources usage and real-time response of the numerical integrator software package.

- Providing proofs and documentation allowing further formal certification of the software toolbox and software package would be an asset.

Technical requirements and constraints

The *aircraft flight model software toolbox* is expected to:

- be delivered as a software suite running on Microsoft Windows XP Operating System preferably;
- run on a current generation PC, and share processing ressources with other applications;
- be delivered with source code (preferably: C, C++, Ada, Java, Fortran, Matlab/Simulink, …);
- be delivered with the tools enabling to perform the production of the executable and the tests of the software.

The *aircraft trajectory numerical integrator software package* is expected to:

- be delivered as a software suite in a basic release running on Microsoft Windows XP Operating System preferably, on a current generation PC, and sharing processing ressources with other applications;
- be delivered with source code (preferably: C, Ada);
- be delivered with test tools enabling to assess computing resources usage and real-time response of the basic release of the executable.

- be portable to other operating systems and platforms by performing minor adaptation of the source code (platform characteristics and compilation options should be contained in specific source packages)
- be delivered with the tools enabling to perform the production of the executable and the tests of the software, to the targetted basic platform but also to other platforms.

Typical expected performance

For given boundary conditions, such as:

- a flight plan defined by major waypoints and aircraft commands along the flight plan, with possible vertical constraints (speed, altitude)
- atmospheric conditions in the area,

the integrator software package should be able to compute a full flight trajectory within 5 seconds, on a current generation computing platform (typical characteristics are to be defined with the topic manager during the problem definition phase).

Support

The model and the tool will be delivered to the topic in order to contribute to the studies on the ITD technologies.

The partner organization shall have the capability to maintain the software toolbox and the software package – i.e. to further adapt, optimize, and produce updated versions.

Several updated versions of these software package and toolbox will be developped during the timeframe of the topic (see §5. Major deliverables and schedule) to allow problems fix and evolutions.

3. Type of work

Development of a software package implementing numerical computation techniques enabling real-time trajectory integration.

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

The candidate organization shall have recognized experience in numerical integration techniques applied to optimal control problems and their implementation in embedded systems (limited computation resources, determinism, …). This experience may have been acquired in other domains than avionics.

The answer to this call for proposal must include a detailed technical description of the solution with the associated evidence of the expertise and pre-existing know how.

5. Major Deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Problem Definition (PD): • Formal definition of the problem to solve • Required input and output data • Constraints • Expected performance	The content of this document is defined and agreed in cooperation with the topic manager or his appointed representative, through technical workshops. The aircraft flight dynamics models for integration required as inputs from the SGO ITD will be agreed with the topic manager at this stage.	01.04.2011

Deliverable	Title	Description (if applicable)	Due date
D2	Technical Specification document (TS)	• Specification of the neural networks techniques applicable to solve the problem • Specification of the numerical computation method • Rationale behind the choice of these methods	01.05.2011
D3	Software package design document (SDD)	Description of the design of the *aircraft flight model software toolbox* and the *aircraft trajectory numerical integrator software package.*	01.06.2011
D4	Validation Test Plan (VTP)	Description of tests cases and tests means to validate the toolbox and the software package. This test plan shall include the acceptance tests to perform at the topic manager request.	01.07.2011
D5	Validation Test Report (VTR), Reference tests data files	Description of tests results and conclusions. This deliverable will be accepted through an acceptance review led by the topic manager.	01.09.2011
D6	Toolbox and software package delivery (V1): • source code • executable for Windows • software production and tests execution tools • software version description document • User Manual document (UM) • (if required) Update of previous documents : TS, SDD, VTP, VTR		01.10.2011
D7	Acceptance Test Report (ATR)	Description of the tests performed at the topic manager facility, their results and conclusions. This deliverable will be accepted through an acceptance review led by the topic manager.	01.11.2011
D8	Problem report and model modification request document (PRD)	Compilation and analysis of problem reports and modification requests agreed in cooperation with the topic manager or his appointed representative.	01.12.2011
D9	Toolbox and software package delivery (V2): • source code • executable for Windows • software production and tests execution tools • software version description document • User Manual document (UM) • (if required) Update of previous documents : TS, SDD, VTP, VTR, ATP, ATR	Release of a software update for problem fixes or evolutions.	01.01.2012

Deliverable	Title	Description (if applicable)	Due date
D10	Final Acceptance Test Report (ATR-2)	Description of the tests performed at the topic manager facility, their results and conclusions. This deliverable will be accepted through an acceptance review led by the topic manager.	01.02.2012
D11	Toolbox and software package delivery (V3): • source code • executable for Windows • software production and tests execution tools • software version description document • User Manual document (UM) • (if required) Update of previous documents : TS, SDD, VTP, VTR, ATP, ATR	Release of a software update for problem fixes or evolutions.	01.04.2012

6. 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 programme

7. Remarks

Reporting

Progress reports will be established by the following elements:

- Description of activities performed
- Specification and development steps achieved
- Numerical simulation / test results technical reports
- Status of the next deliverables and review milestones

Meeting and review policy

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

Co-ordination with other projects

- The proposal shall foresee the establishment of links with relevant AAT - FP7 activities (particularly the project REACT4C) in order to avoid duplications and create synergies. This should be reflected in the work programme and the handling of IP/dissemination.

Clean Sky - Technology Evaluator

Identification	ITD - AREA - TOPIC	topics	VALUE	MAX FUND
JTI-CS-TEV	Clean Sky - Technology Evaluator	0		

No topics from Technology Evaluator are included in this call.