Clean Sky Joint Undertaking
Call SP1-JTI-CS-2011-01

European Commission
Research Directorates

Call for Proposals:

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

Call Text

Call Identifier

SP1-JTI-CS-2011-01

Part B - SAGE

Index

Document track changes

Page/topic	*Original*	*Correction or modification*

Specialised and technical assistance:

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

EPSS Help desk support@epss-fp7.org

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

Introduction

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

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

Each Topic fiche addresses the following points:

- Topic manager (not to be published)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

The maximum allowed Topic budget relates to the total scope of work. A Maximum funding is also indicated.

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

Recommendation to applicants:

Proposal Submission Forms

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

Collaborative Project

A3.2: Budget

Proposal Number: nnnnnn — Proposal Acronym: yyyyyyyyy

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

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

Eligibility criteria

All applicants are requested to verify their actual status of "**affiliate**" with respect to the members of the relevant ITD for whose topic(s) they wish to submit a proposal.
Applicants who are affiliated to any leader or associate of an ITD will be declared not eligible for the topics of that ITD.
Refer to art.12 of the Statute (*Council Regulation (EC) No 71/2007 of 20 December 2007 setting up the Clean Sky Joint Undertaking*) and to page 8 of the Guidelines.

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: 10 February 2011**
- **Call close: 3 May 2011, 17:00**

- Evaluations (indicative): 23-27 May 2011

- Start of negotiations (indicative): 01 July 2011
- Final date for signature of GA by Partner: 31 August 2011
- Final date for signature of GA by Clean Sky JU: 15 September 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:

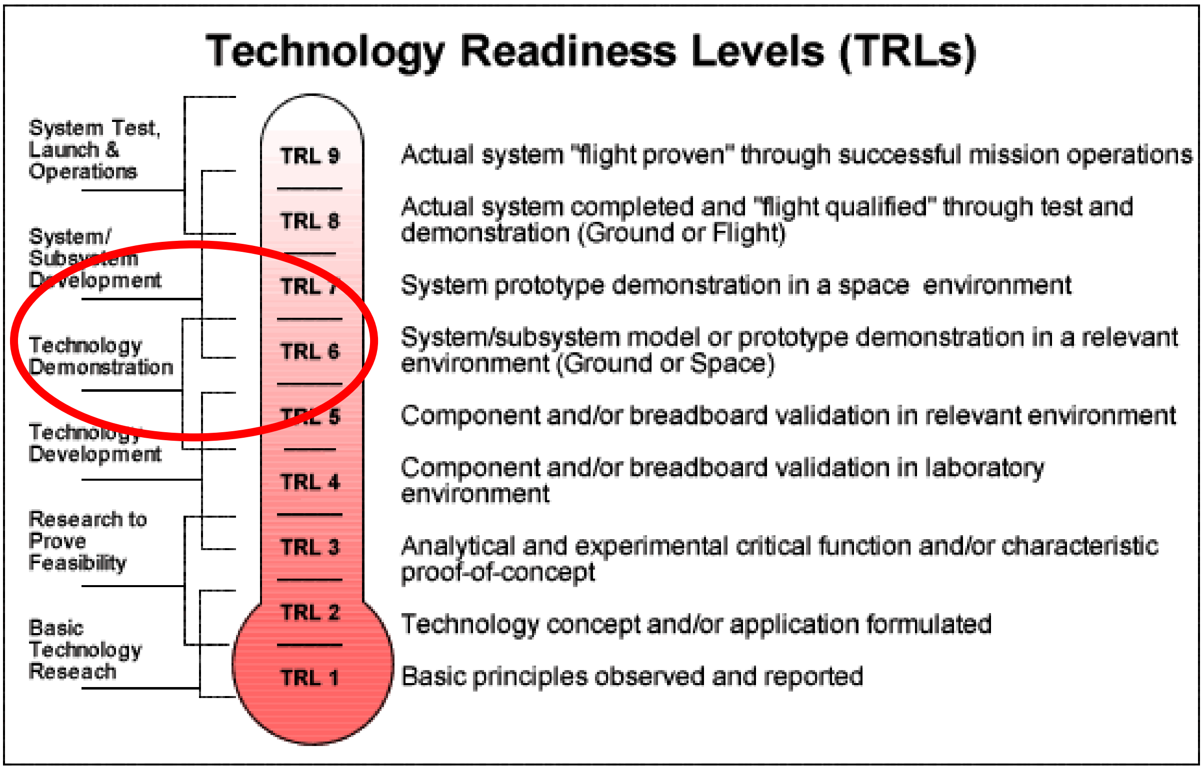
info-call-2011-01@cleansky.eu

Questions received until **25 March 2011** 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), together with the answers provided by the topic managers.

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

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



Clean Sky Joint Undertaking

Call SP1-JTI-CS-2011-01

Identification	ITD - AREA - TOPIC	topics	VALUE	MAX FUND
JTI-CS-ECO	**Clean Sky - EcoDesign**	**12**	**6.410.000**	**4.807.500**
JTI-CS-ECO-01	*Area-01 - EDA (Eco-Design for Airframe)*		2.050.000	
JTI-CS-2011-1-ECO-01-018	Environmental Data Models and Interface development		720.000	
JTI-CS-2011-1-ECO-01-019	Borate-free cleaners used in anodizing processes		100.000	
JTI-CS-2011-1-ECO-01-020	Chromate-free sealing of TSA		100.000	
JTI-CS-2011-1-ECO-01-021	Industrialisation Set-Up of Thermoplastics «In situ » Consolidation Process		290.000	
JTI-CS-2011-1-ECO-01-022	Development of flexible inductive thin sheet heating device for FRP repair applications		200.000	
JTI-CS-2011-1-ECO-01-023	To develop recycling technologies of aeronautical composite materials through mechano-physical approaches		140.000	
JTI-CS-2011-1-ECO-01-024	Simplified LCA Tool development		250.000	
JTI-CS-2011-1-ECO-01-025	Production of yarns and fabrics based on recycled carbon fibres (CFs)		250.000	
JTI-CS-ECO-02	*Area-02 - EDS (Eco-Design for Systems)*		4.360.000	
JTI-CS-2011-1-ECO-02-008	Electrical Model of Generic Architecture Electrical Power Distribution		300.000	
JTI-CS-2011-1-ECO-02-009	Alternator with active power rectification and health monitoring		1.700.000	
JTI-CS-2011-1-ECO-02-010	Development, Construction and Integration of Systems for Ground Thermal Test Bench		2.000.000	
JTI-CS-2011-1-ECO-02-011	Heat pipe for critical applications		360.000	
JTI-CS-GRA	**Clean Sky - Green Regional Aircraft**	**6**	**1.330.000**	**997.500**
JTI-CS-GRA-01	*Area-01 - Low weight configurations*		770.000	
JTI-CS-2011-1-GRA-01-035	Smart maintenance technologies		220.000	
JTI-CS-2011-1-GRA-01-036	Development of methodology for selection and integration of sensors in fuselage stiffened panels. Testing scheme,		100.000	
JTI-CS-2011-1-GRA-01-037	Advanced fuselage and wing structure based on innovative alumiunium lithium alloy - numerical trade off study and		450.000	
JTI-CS-GRA-02	*Area-02 - Low noise configurations*		460.000	
JTI-CS-2011-1-GRA-02-015	Advanced concepts for trailing edge morphing wings - Design and Manufacturing of test rig and test samples - Test		210.000	
JTI-CS-2011-1-GRA-02-016	Novel nose wheel evolution for noise reduction		250.000	
JTI-CS-GRA-03	*Area-03 - All electric aircraft*			
JTI-CS-GRA-04	*Area-04 - Mission and trajectory Management*			
JTI-CS-GRA-05	*Area-05 - New configurations*		100.000	
JTI-CS-2011-1-GRA-05-006	Updated Regional traffic scenario to upgrade Requirements for "Future Regional Aircraft".		100.000	
JTI-CS-GRC	**Clean Sky - Green Rotorcraft**	**5**	**3.150.000**	**2.362.500**
JTI-CS-GRC-01	*Area-01 - Innovative Rotor Blades*			
JTI-CS-GRC-02	*Area-02 - Reduced Drag of rotorcraft*			
JTI-CS-GRC-03	*Area-03 - Integration of innovative electrical systems*		2.150.000	
JTI-CS-2011-1-GRC-03-006	EMA for utility consumer systems: EMA for Landing Gear		1.000.000	
JTI-CS-2011-1-GRC-03-007	Innovative Dynamic Rotor Brake		700.000	
JTI-CS-2011-1-GRC-03-008	Innovative High Voltage Energy Storage System for Advanced Rotorcraft Integration.		450.000	
JTI-CS-GRC-04	*Area-04 - Installation of diesel engines on light helicopters*			
JTI-CS-GRC-05	*Area-05 - Environmentally friendly flight paths*		800.000	
JTI-CS-2011-1-GRC-05-005	Integrated ATC/tiltrotor simulation of low-noise procedures and evaluation of the impact on operators		800.000	
JTI-CS-GRC-06	*Area-06 - Eco Design for Rotorcraft*		200.000	
JTI-CS-2011-1-GRC-06-003	Dismantling and recycling of ecodesigned helicopter demonstrators		200.000	
JTI-CS-SAGE	**Clean Sky - Sustainable and Green Engines**	**18**	**20.000.000**	**15.000.000**
JTI-CS-SAGE-01	*Area-01 - Geared Open Rotor*		1.000.000	
JTI-CS-2011-1-SAGE-01-001	Lean Burn Control System Verification Rig		1.000.000	
JTI-CS-SAGE-02	*Area-02 - Direct Drive Open Rotor*		4.500.000	
JTI-CS-2011-1-SAGE-02-006	Pitch Change Mechanism key technologies maturation		2.000.000	
JTI-CS-2011-1-SAGE-02-007	PCM kinematic demonstration		2.200.000	
JTI-CS-2011-1-SAGE-02-008	Propellers electrical de-icing system: reliability assessment of key technologies for high temperature electrical machines		300.000	
JTI-CS-SAGE-03	*Area-03 - Large 3-shaft turbofan*		6.900.000	
JTI-CS-2011-1-SAGE-03-007	Large 3-shaft Demonstrator – Core Turbomachinery – High Temperature Flexible PCB		600.000	
JTI-CS-2011-1-SAGE-03-009	Large 3-shaft Demonstrator – Aeroengine intake acoustic liner technology development		5.000.000	
JTI-CS-2011-1-SAGE-03-010	Steel casting process advancement		800.000	
JTI-CS-2011-1-SAGE-03-011	Advanced press forming and hardening of high strength steels		500.000	
JTI-CS-SAGE-04	*Area-04 - Geared Turbofan*		5.300.000	
JTI-CS-2011-1-SAGE-04-008	Casting process optimization and validation of hollow multivane clusters with thin walls and trailing edges		600.000	
JTI-CS-2011-1-SAGE-04-009	Integrating forging- and process-simulation into SAGE4 GTF LPT rotor design		400.000	
JTI-CS-2011-1-SAGE-04-010	Total Measurement System for Geometry and Surface Inspection of bladed Disks (TOMMI)		1.300.000	
JTI-CS-2011-1-SAGE-04-011	Implementation of Carbon-Nanotube Rein-forced Aluminum for Aerospace Heat Ex-changer Applications		1.000.000	
JTI-CS-2011-1-SAGE-04-012	Electric Smart Engine Actuator		1.000.000	
JTI-CS-2011-1-SAGE-04-013	High temperature Ni-based alloy forging process advancement		500.000	
JTI-CS-2011-1-SAGE-04-014	High temperature Ni-based super alloy casting process advancement		500.000	
JTI-CS-SAGE-05	*Area-05 - Turboshaft*		2.300.000	
JTI-CS-2011-1-SAGE-05-013	Feasibility study and prototypes manufacturing of oil tank in thermoplastic for Helicopter Engine		450.000	
JTI-CS-2011-1-SAGE-05-014	Hot environment unsteady pressure sensors		750.000	
JTI-CS-2011-1-SAGE-05-015	Development of Quiet exhaust noise attenuation technologies		1.100.000	
JTI-CS-SFWA	**Clean Sky - Smart Fixed Wing Aircraft**	**12**	**9.900.000**	**7.425.000**
JTI-CS-SFWA-01	*Area01 – Smart Wing Technology*		2.100.000	
JTI-CS-2011-01-SFWA-01-034	Analysis of sensitivity/robustness of distributed micron-sized roughness elements (MSR) for transition delay		500.000	
JTI-CS-2011-01-SFWA-01-035	Grooved paint surface manufacturing and aerodynamic testing		350.000	
JTI-CS-2011-01-SFWA-01-036	Automated riblet application on relevant aircraft parts		550.000	
JTI-CS-2011-01-SFWA-01-037	Basic wind tunnel investigation to explore the use of Active Flow Control technology for aerodynamic load control		250.000	
JTI-CS-2011-01-SFWA-01-038	High Voltage amplifier for MEMS-based Active Flow Control (AFC) actuators		450.000	
JTI-CS-SFWA-02	*Area02 – New Configuration*		3.150.000	
JTI-CS-2011-01-SFWA-02-012	Design and manufacturing of an innovative shield - A		70.000	
JTI-CS-2011-01-SFWA-02-013	Design and manufacturing of an innovative shield - B		90.000	
JTI-CS-2011-01-SFWA-02-014	Design and manufacturing of an innovative shield - C		90.000	
JTI-CS-2011-01-SFWA-02-015	Ground Based Structural and Systems Demonstrator Phase 3 – Component and sub-system manufacture		2.900.000	
JTI-CS-SFWA-03	*Area03 – Flight Demonstrators*		4.650.000	
JTI-CS-2011-1-SFWA-03-006	Outer wing assembly for tooling manufacturing		3.000.000	
JTI-CS-2011-1-SFWA-03-007	Low drag wing foam cover for flight test		900.000	
JTI-CS-2011-1-SFWA-03-008	Acoustic Inlet Lip panel large scale endurance demonstrator		750.000	
JTI-CS-SGO	**Clean Sky - Systems for Green Operations**	**5**	**1.700.000**	**1.275.000**
JTI-CS-SGO-01	*Area-01 - Definition of Aircraft Solutions and explotation strategies*			
JTI-CS-SGO-02	*Area-02 - Management of Aircraft Energy*		1.450.000	
JTI-CS-2011-1-SGO-02-014	Construction of evaluation Power Modules to a given design		250.000	
JTI-CS-2011-1-SGO-02-026	Modelica Model Library Development Part I		300.000	
JTI-CS-2011-1-SGO-02-032	Current return simulation (methodology & tool)		400.000	
JTI-CS-2011-1-SGO-02-033	Optimisation of coating for low pressure operation of power electronics and identification of pass and fail criteria for r		500.000	
JTI-CS-SGO-03	*Area-03 - Management of Trajectory and Mission*		250.000	
JTI-CS-2011-1-SGO-03-011	Flight operations for novel Continous Descent Operations		250.000	
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 (€)	58	42.490.000	31.867.500

Clean Sky - Sustainable and Green Engines

Identification	ITD - AREA - TOPIC	topics	VALUE	MAX FUND
JTI-CS-SAGE	**Clean Sky - Sustainable and Green Engines**	**18**	**20.000.000**	**15.000.000**
JTI-CS-SAGE-01	*Area-01 - Geared Open Rotor*		**1.000.000**	
JTI-CS-2011-1-SAGE-01-001	Lean Burn Control System Verification Rig		1.000.000	
JTI-CS-SAGE-02	*Area-02 - Direct Drive Open Rotor*		**4.500.000**	
JTI-CS-2011-1-SAGE-02-006	Pitch Change Mechanism key technologies maturation		2.000.000	
JTI-CS-2011-1-SAGE-02-007	PCM kinematic demonstration		2.200.000	
JTI-CS-2011-1-SAGE-02-008	Propellers electrical de-icing system: reliability assessment of key technologies for high temperature electrical machines		300.000	
JTI-CS-SAGE-03	*Area-03 - Large 3-shaft turbofan*		**6.900.000**	
JTI-CS-2011-1-SAGE-03-007	Large 3-shaft Demonstrator – Core Turbomachinery – High Temperature Flexible PCB		600.000	
JTI-CS-2011-1-SAGE-03-009	Large 3-shaft Demonstrator – Aeroengine intake acoustic liner technology development		5.000.000	
JTI-CS-2011-1-SAGE-03-010	Steel casting process advancement		800.000	
JTI-CS-2011-1-SAGE-03-011	Advanced press forming and hardening of high strength steels		500.000	
JTI-CS-SAGE-04	*Area-04 - Geared Turbofan*		**5.300.000**	
JTI-CS-2011-1-SAGE-04-008	Casting process optimization and validation of hollow multivane clusters with thin walls and trailing edges		600.000	
JTI-CS-2011-1-SAGE-04-009	Integrating forging- and process-simulation into SAGE4 GTF LPT rotor design		400.000	
JTI-CS-2011-1-SAGE-04-010	Total Measurement System for Geometry and Surface Inspection of bladed Disks (TOMMI)		1.300.000	
JTI-CS-2011-1-SAGE-04-011	Implementation of Carbon-Nanotube Rein-forced Aluminum for Aerospace Heat Ex-changer Applications		1.000.000	
JTI-CS-2011-1-SAGE-04-012	Electric Smart Engine Actuator		1.000.000	
JTI-CS-2011-1-SAGE-04-013	High temperature Ni-based alloy forging process advancement		500.000	
JTI-CS-2011-1-SAGE-04-014	High temperature Ni-based super alloy casting process advancement		500.000	
JTI-CS-SAGE-05	*Area-05 - Turboshaft*		**2.300.000**	
JTI-CS-2011-1-SAGE-05-013	Feasibility study and prototypes manufacturing of oil tank in thermoplastic for Helicopter Engine		450.000	
JTI-CS-2011-1-SAGE-05-014	Hot environment unsteady pressure sensors		750.000	
JTI-CS-2011-1-SAGE-05-015	Development of Quiet exhaust noise attenuation technologies		1.100.000	

Topic Description

CfP topic number	Title		
JTI-CS-2011-1-SAGE-01-001	**Lean Burn Control System Verification Rig**	**Start date**	*Jun 2011*
		End date	*Jun 2012*

1. Topic Description

The SAGE1 project has launched an action to prepare for a lean burn combustion system demonstration, using a large, high bypass gas turbine engine.

Lean burn technologies will contribute to lower emission engines, particularly helping to reduce the aviation discharge of nitrous oxides. A key technology element within this demonstration will be the realisation of a control system capable of managing the supply of fuel to a lean burn combustion system. This control system will be required to be designed, developed and installed onto a conventional turbofan that has been modified to incorporate lean burn combustion. This engine will then undergo a range of experiments, including flight testing, to enable technology validation at the system / whole engine level and across the operational envelope.

A lean burn combustion system will require a highly complex control system design in order to provide the required advances in system functionality, which include the control of fuel to each burner in the combustion system and the precise management of fuel flows between Pilot and Mains nozzles across the complete range of engine operating conditions.

Fundamental to the control system design, development and implementation is verification of system performance, considering a range of factors that include:

a) Interaction with the donor-engine fuel system, to ensure no adverse effects

c) System performance across the operational envelope

b) Fault insertion to represent abnormal operation of the system

d) Confirmation of adequate sensing and acquisition with the system

In order to achieve the above, a verification facility able to represent the full geometry of the on-engine installation [pipework assemblies >1.5m in diameter for a large civil turbofan engine] and simulate system dynamic response, including local effects, will be required. Test interfaces that support multi-controller / communication-link evaluation should also be available.

Ideally, the facility should be designed to provide a level of installation / interface flexibility to enable system architectural aspects to be explored and a range of component technologies to be evaluated.

The applicant or consortium shall in particular perform the following tasks:

<u>Task 1: Lean Burn Control System Test Facility Definition</u>

Work with stakeholders to develop a definition of a test facility to meet the requirements of the lean-burn control system verification strategy. The innovative nature of an advanced control system will likely require novel verification techniques to fully explore the capabilities and limitations of the system.

This activity delivers a test facility definition, including traceability to the lean-burn control system verification strategy.

<u>Task 2: Lean Burn Control System Test Facility Design</u>

Design of the test facility, including hydro-mechanical, electrical, instrumentation and data acquisition equipment, along with real time engine simulation capability. The design shall be reviewed to ensure compatibility with the verification strategy and any additional stakeholder requirements.

<u>Task 3: Lean Burn Control System Test Facility Build</u>

Construction of a lean-burn control system test facility to the design generated in Task 2.

Task 4: Lean Burn Control System Test Facility Commissioning

Commissioning of the lean-burn control system test facility to confirm functionality and test readiness.

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

The applicant or consortium needs to demonstrate pedigree in the provison of complex system test facilities, including experience of aerospace fuel and gas turbine control systems

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

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1.1	System Test Facility Definition	Lean burn control system test facility definition - including traceability to the system verification strategy.	T_o + 2 months
D1.2	System Test Facility Design	Lean burn control system test facility design review – detailed overview of the facility design & how it will meet performance / regulatory requirements and any additional Stakeholder needs.	T_o + 6 months
D1.3	Completion of Commissioning of Lean Burn Control System Test Facility	Test facility commissioning report – demonstration of the facility meeting the design intent.	T_o + 12 months

Note: T_o is the effective date of contract.

4. Topic value (€)

The total value of this work package shall not exceed:

1,000,000 €

[one million euro]

This topic value is a maximum gross value for the work package.

Awards of up to 50-75% of this value may be made by the Clean Sky Joint Undertaking.

5. Remarks

Organisations interested in this call are encouraged to contact Topic Manager via the Clean Sky Joint Undertaking to sign a non-disclosure agreement after which a more specific rig specification will be released. This will help the applicant to make a more specific and complete proposal.

Topic Description

CfP topic number	Title		
JTI-CS-2011-01-SAGE-02-006	**Pitch Change Mechanism key technologies maturation**	End date	*20/12/2012*
		Start date	*01/06/2011*

1. Topic Description

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

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

During concept analysis, several PCM candidates have been studied and a preliminary dowselection made. However these candidates are based on key technologies which will bring the required level of reliability to the system.

To select the best PCM solution, these key technologies require maturation tests.

Detailed kinematic & dynamic behaviour of 3 concepts is also to be analysed by simulation.

Scope of call for proposal:

- manufacturing and/or procurement of key technology prototypes based on available detailed design
- detail design of test benches and manufacturing or procurement of components based on existing test plan & test bench squetches
- design and procurement of instrumentation required for the different tests
- Test benches modifications and commissionnning including test bench control and instrumentation
- Highly Accelerated Life Tests
- Modification / optimization of key components during HALT tests to improve there robustness. This task will require re-design activities plus make or procurement of modified parts
- Tests results analysis
- Modelling of 3 PCM concepts and Detail kinematic & dynamic simulation to assess their behaviour regarding manufacturing tolerances, environment constraints, and external loads
- PCM concepts comparizon based on test & simulation results to select a baseline architecture
- Management and reporting activities related to the technical activities listed above

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

Experience in design and/or manufacturing of Pitch Change Mechanisms or similar technologies for aircarft engines is mandatory

Experience in test bench design and modification is mandatory

Experience in HALT tests for aeronautic components is mandatory

Availability of test benches to support test campaign is mandatory

English langage in mandatory

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
1	Development plan	Including detailed risk analysis and mitigation proposal	T0 + 1 month
2	Test benches detailed Design including instrumentation and control	Critical Design Review	T0 + 2 months
3	Key technology prototypes	Hardware availability / Test Readiness Review	T0 + 6 months
4	Test benches commissioning including test bench control & instrumentation		T0 + 6 months
5	Preliminary HALT test report		T0 + 12 months
6	Final conclusions	Final Review	T0 + 18 months

4. Topic value (€)

The total value of this work package shall not exceed

2,000,000 €

[two millions euro]

including company own funding & JU subvention

This topic value is a maximum gross value for the work package.

Awards of up to 50-75% of this value may be made by the Clean Sky Joint Undertaking.

5. Remarks

9 key technologies are identified for HALT tests (bearings, seals, joints, complete actuators....)

Regular meetings (weekly basis) will be held with Topic Manager to deal with technical and program questions. Physical workshops will be organized approximately every 4 months at Topic Manager site and/or on test bench site

Topic Description

CfP topic number	Title		
JTI-CS-2011-1-SAGE-02-007	**PCM kinematic demonstration**	End date	*20/12/2012*
		Start date	*01/06/2011*

1. Topic Description

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

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

During concept design phase, several PCM candidates have been studied and a preliminary dowselection made.

One of these concepts has been identified as very promising in term of engine impact (overall weight, size and fuel burn benefit) but is based on a very innovative kinematic that needs more validation and especially a full scale demonstration.

Scope of call for proposal:

- Full scale demonstration of the kinematic of the PCM for the front rotor in a simulated environment representative of the external loads, especially centrifugal loading.

List of activities:

- analysis and definition of test plan
- preliminary & detailed design of kinematic components based on an existing conceptual design of the mechanism with respect of target stiffness, clearances and frictions
- Introduction of devices in the kinematic to simulate geometric variations &/or modifications in the clearances and frictions of the mechanism during the tests
- preliminary and detailed design of the test bench simulating the external loads on the system
- detailed design of a test bench actuation system able to move the mechanism in a representative manner.
- preliminary and detailed design of instrumentation systems required during the test
- manufacturing and/or procurement of the system to test, test bench, test instrumentation and test controls components required to run the test
- assembly and comissionning of the system to test
- assembly and commisionning of the test bench including its control system and instrumentation system
- Campaign of tests of the mechanism to demonstrate robustness of the kinematics including simulation of dissimetry in the mechanism due to geometric variations of the components, different clearances and friction levels
- Tests results analysis and proposal for system optimization
- management and reporting activities related to the technical activities listed above

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

Experience in design and/or manufacturing of Pitch Change Mechanisms or similar kinematics for aircaft engines is mandatory

Experience in test bench design and modification is mandatory

Availability of test bench to support test campaign is mandatory

English langage in mandatory

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
	Development plan	Including detailed risk analysis and mitigation proposal	T0 + 1 month
	Preliminary test plan	Preliminary Design Review	T0 + 3 months
	Preliminary design of the system made of kinematic to test + test bench + test control system + instrumentation		T0 + 3 months
	Detailed design of the system to test ¨+ test bench + test control system + instrumentation	Critical Design Review	T0 + 6 months
	Test plan		T0 + 9 months
	System to test + test bench commissioning including test control and instrumentation	System to test & test bench availability / Test Readiness Review	T0 + 12 months
	Preliminary test report		T0 + 15 months
	Final conclusions	Final Review	T0 + 18 months

4. Topic value (€)

The total value of this work package shall not exceed:

2,200,000 €

[two million two hundred thousand euro]

including company own funding & JU subvention

This topic value is a maximum gross value for the work package.

Awards of up to 50-75% of this value may be made by the Clean Sky Joint Undertaking.

5. Remarks

External diameter of system to test is approximately 1.5 metres

Normal rotating speeds of the system is up to 1000 rpm

Regular meetings (weekly basis) will be held with Topic Manager to deal with technical and program questions. Physical workshops will be organized approximately every 3 to 4 months at Topic Manager site and/or on test bench site

Topic Description

CfP topic number	Title		
JTI-CS-2011-1-SAGE-02-008	**Propellers electrical de-icing system: reliability assessment of key technologies for high temperature electrical machines**	Start date	*tbd*
		End date	*01/09/2012*

1. Topic Description

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

The SAGE2 Demonstrator incorporates two conter-rotating propellers, which should be deiced. An electrical deicing system is studied to supply and transfer the power necessary to the deicing. For this system several type of electrical machines are considered. High reliability of such machines in a harsh environment (high temperature) is a key target for the project.

The activities of this topic concern the assessment of reliability of materials and windings for high temperature electrical machines through tests campaigns.

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

Task 1: Project management:

Planning and steering activities for the project.

Quality management of the project.

Task 2: Preparation of test plan

Identify the best candidate materials / technologies consistent with the requirements of the application through extensive bibliography

Provide a report describing the state of the art

Analyze the risks associated with these materials (properties of this material, aging with cycling at high temperature) and the risks related with the forming and assembly of these materials

Define methodology, test vehicles and test plan. 2 phases are expected:

1. material testing to check high temperature behaviour (TGA for example)

2. reliability tests on relevant test vehicles (windings) to be defined in consistency with electrical machine design

Task 3: Tests phase 1 - Material testing

Supply the necessary materials

Adapt the tests benches / equipments when necessary

Carry out the material testing

Interprate the results of the tests and adapt the phase 2 test plan if necessary

Task 4: Test phase 2 - Reliability tests on relevant test vehicles

Supply/ realize the test vehicles (windings)

Adapt the test benches / equipments when necessary

Provide full test reports

Task 5: Interpretation of test results and recommendations

Analyze test results and compare with bibliographical sources

Make recommendations for the materials, the forming and assembly processes to use for high temperature electrical machines.

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

NB: a consortium of laboratories and/or compagnies may answer the call

Extensive experience in the field of material testing and characterization

Experience in electrotechnics The applicant should have at disposal equipements and test means for material characterization and high temperature testing of windings English language is mandatory

3. Major deliverables and schedule

	2011				2012			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Task 1			■	■	■	■	■	
Task 2			■	■				
Task 3				■	■	■		
Task 4					■	■		
Task 5						■	■	

Deliverable	Title	Description (if applicable)	Due date
D1-1	Monthly progress reports		Every month
D2-1	Report on the state of the art		Sept 2011
D2-2	Test plan and methodology – issue 1		Sept 2011
D3-1	Test reports on material tests & analysis on test results and recommendations for task 4		Dec 2011
D3-2	Test reports on complementary tests on materials		June 2012
D4-1	Test reports on tests on windings		June 2012
D5-1	Test results analysis & recommendations		Dec 2012

4. Topic value (€)

The total value of this work package shall not exceed: **200 000€** **[two hundred thousand Euros]** This topic value is a maximum gross value for the work package. Awards of up to 50-75% of this value may be made by the Clean Sky Joint Undertaking.

5. Remarks

If applicable

Topic Description

CfP topic number	Title		
JTI-CS-2011-5-SAGE-03-007	**Large 3-shaft Demonstrator – Core Turbomachinery – High Temperature Flexible Printed Circuit Board**	Start date	*Aug 2011*
		End date	*Dec 2013*

1. Topic Description

SAGE3 project aims at development and demonstration of a large 3-shaft bypass engine Demonstrator. The technological challenge is to increase the level of control on the engine core without the burden of heavy interconnection systems.

In this context, RTD activities are foreseen on developing a high temperature flexible Printed Circuit Board (PCB) material to allow control and integrated interconnect systems to be introduced onto the engine core, with the objective to demonstrate this technology to Technology Readiness Level (TRL)6.

The minimum temperature capability of interest is 260°C, but technologies capable of higher temperatures (up to 400°C) would be strongly preferred.

The activity needs to comply with the requirements developed within the concept design phase presently ongoing at SAGE 3 level.

The partner shall in particular perform the following tasks:

Task 1: Support High Temperature design & validation

The design of the high temperature interconnect system will be carried out by Rolls-Royce. However the manufacturing partner is required to support this activity to ensure the design is realisable. The types of signals to be carried is outlined in Figure 1 below, a more detailed specification will be supplied during the design phase. The following activities are required:

- Support, from early phases of high temperature flexible PCB system design, through to material and process development. This includes where possible the flexible PCB, the interconnect and the integration of the system. If the interconnect or integration part of this proposal is not within the scope of the proposal this should be clearly stated.
- Develop the design specification and assist in definition both the electrical and mechanical limitations. Support design for manufacture, design for cost and design for service events during the design phase. Support the Manufacturing Capability Readiness reviews which are one part of the validation assessment of the high temperature flexible PCB.
- As well as providing manufactured articles (see task 3) define and conduct the validation tests required to achieve TRL6 and conduct reviews to verify that the required maturity has been reached.
- Hardware should be capable of being produced to achieve full-scale requirements that would suitable for demonstration on the core of a Trent 1000, should the verification strategy or manufacturing proving strategy so require.

Task 2: Identification, Selection and Development of Materials and Manufacturing Processes for High Temperature PCB

The design and resulting manufacturing methods for the high temperature flexible PCB is a result of the programme, but it is anticipated that high temperature pressing, assembly and inspection technologies (e.g. bonding and NDE techniques) will be key.

- Supported by Rolls-Royce, identify suitable materials and manufacturing processes for the high temperature flexible PCB.
- Perform sufficient manufacturing trials to select cost-effective materials and processes. Then, supported by Rolls-Royce, down-select the final materials and manufacturing processes for the high temperature flexible PCB.
- Develop the manufacturing processes to ensure that the resulting high temperature flexible PCB can meet functional (e.g. geometry), quality (e.g. defects) and cost. As well as the primary

manufacturing process development, inspection and quality procedures (to agreed quality processes) should be developed.

- Although in this programme only a limited number of high temperature flexible PCBs will be produced, the quality and cost implications of the processes for volume supply should be considered by the partner.

Task 3 : Manufacturing of High Temperature Flexible PCBs

- Develop and design suitable tooling for the PCB manufacture. Procure the required tooling and any bought-in parts.
- Manufacture and supply to Rolls-Royce full-size high temperature flexible PCBs for engine and rig running plus spares to demonstrate core zone 2 and zone 3 capability (about 15 PCBs in total with lengths of up to 5m).
- Provide documentation associated with the process control and inspection of the high temperature flexible PCB to support the validation of the high temperature flexible PCB in task 1.

Figure 1: Outline of Signal Requirements

Signal	Description	Signal Range	Signal Frequency	Source Impedance	Cable and Sensor Impedance
Thermocouple	Low Level DC	2.032mV – 48.838mV typical	dc	High – diff amp	<=50Ω resistive
AFDX	High Speed Controlled Impedance	+/-2.5V pulse differential	10 base-T	100Ω	100Ω
Speed Probe	High Voltage AC	0-300V pk-pk	100Hz – 20kHz	100kΩ differential	1 - 1000Ω resistive
Solenoid	High Power Digital	31.6Vdc to 50Vdc supply variation tolerated. Pull-in Current 150mA, Hold-in Current 100mA, Drop-out Current <5mA. Current drive output 7.8 to 250mA nominal, up to 500mA fault current.	3.12kHz PWM	2Ω	25 – 150Ω resistive

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

Extensive experience in the detail design, development and manufacture of high temperature PCB laminate materials for high performance applications. Experience of suitable quality control systems is essential.

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

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

The partner needs to be in the position to have access to the manufacturing facilities suitable for making full scale PCB.

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

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

Technical/program documentation, including planning, drawings, manufacturing and inspection reports, must be made available to Rolls-Royce.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1.1	High temperature PCB PDR	Preliminary Design Review	Jan 2012
D1.2	High temperature PCB CDR	Critical Design Review	June 2012
D1.3	Capability Readiness Review documentation	Documentation suitable to demonstrate that TRL=6 has been reached	Oct 2013
D2.1	Documentation to substantiate lab development of PCB's.	Analysis report of preliminary manufacturing development suitable to demonstrate ability to manufacture full-size parts.	June 2012
D2.2	Quality plans	Documentation to underwrite the manufacturing of quality parts	Sept 2012
D2.3	Documentation to substantiate full-size PCB manufacture	Analysis report of final high temp PCB manufacturing and inspection suitable to prove key attributes have been reached.	Nov 2012
D3.1	Manufacturing articles for engine fit checks & or engine test	Delivery of approx 15 high temperature flexible PCB and associated conformance documents.	Dec 2012

4. Topic value (€)

The value of this topic is:

600,000/00 €
[six hundred thousand euro]

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

5. Remarks

If applicable

Topic Description

CfP topic number	Title		
JTI-CS-2011-1-SAGE-03-009	**Large 3-shaft Demonstrator – Aeroengine intake acoustic liner technology development**	Start date	*Jul. 2011*
		End date	*Dec. 2013*

1. Topic Description

SAGE3 project aims at development and demonstration of a large 3-shaft bypass engine Demonstrator. The Demonstrator programme has three builds, the first runs through quarters 2 to 4 in 2012, the second in quarters 1 and 2 2013 and the third build in late 2013.

A large role in the efficiency of the overall engine is played by the fan and bypass system. The technological challenge is to increase the bypass ratio to move as large a mass flow of air as efficiently as possible while reducing the weight of the fan and associated structures. Lightweight, effective acoustic liners will be required to meet both the weight and noise emissions requirements.

An opportunity therefore exists to develop the state of the art in intake liner acoustic and mechanical design and to test this liner in the engine environment on the second build of the Demonstrator. Proposals that include research to reduce the cost, weight and durability of liners and/or improve their acoustic properties are preferred.

It is envisaged that a partner supplied liner barrel will be mated to a Topic Manager supplied intake lip representation. The aerodynamic lines of the intake will be supplied by Topic Manager.

The partner shall in particular perform the following tasks:

Task 1: Design and analysis of novel intake acoustic liner

The partner will conduct the mechanical concept and detail design of the acoustic liner against a Topic Manager specification. The liner parameters (cell size, depth etc) will be optimised by Topic Manager taking into account the type of liner that the partner wishes to develop e.g, single or dual layer. The liner design must minimise any circumferential variation of the acoustic properties.

Although a liner structurally representative of a production solution would be preferred, as this is to be used for ground test only, a liner with separate structural backing would be acceptable.

The intake lines will be supplied by Roll-Royce and agreed with the partner. The expected size of the liner barrel test article is between 1000 and 1200 mm length with a maximum flow surface diameter of 2900 mm. Topic Manager has defined a preliminary fully 3-D shape for the test intake, but if there is little advantage in terms of the Partner's technology development in designing and manufacturing a 3-D shape, an alternative aerodynamic line as a surface of revolution can be defined.

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

Task 2: Intake acoustic liner manufacturing and assembly

The partner will manufacture one acoustic liner barrel test article (including any structural support/ backing) fitted with flanges suitable for attaching to the engine and to the intake lip hardware. These interfaces will be mutually agreed during the design phase.

Instrumentation requirements will be mutually agreed with the Partner but it is envisaged that this will include a row of ten kulites equispaced axially through the flight intake at either port or starboard sideline to validate the acoustic properties.

The test article should be designed to withstand 500 hours running on a sea level static test bed without requiring any maintenance.

Documentation justifying that the articles are fit for purpose for their testing is required.

The partner may be asked for samples of the acoustic liner.

Task 3: Intake liner validation support

The partner shall support the engine demonstrator test through the preparation, test and appraisal phases. During the final preparation and test it is envisaged that on-site support will be required.

It should be noted that the second build of the demonstrator will be tested on an indoor test bed at the Topic Manager Derby facility and no outdoor testing is planned. Thus acoustic validation will be via in-duct measurements.

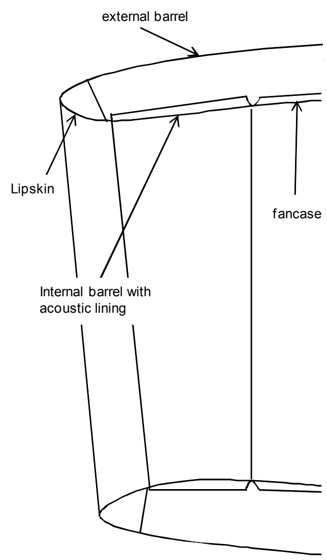


Figure 1: Schematic section of a typical intake

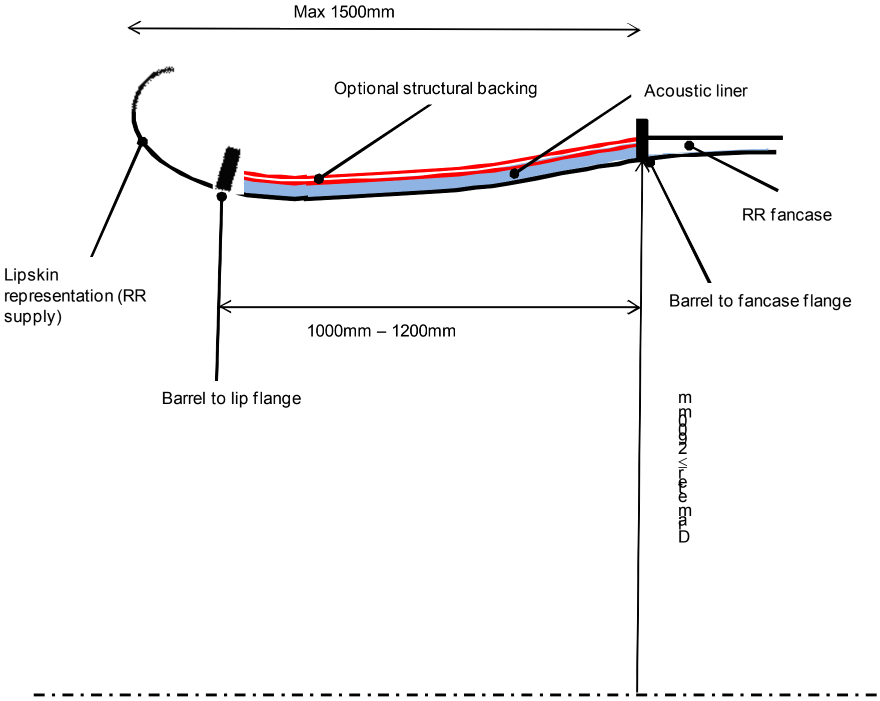


Figure 2: Schematic of proposed test intake

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

Experience in the concept and detail design, development and manufacture of acoustic liners for aero-engine intakes is preferred. Experience of suitable quality control systems is essential.

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

Experience in aerospace R&T programmes.

The partner needs to demonstrate access to the manufacturing facilities required to meet the goals. Of particular interest is the ability to manufacture hardware of the size required.

The activity will be managed with a Phase & Gate approach and management plan has to be provided. The partner will be expected to conduct risk management and share visibility of the risks. Topic Manager will approve gates and authorize progress to subsequent phases.

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

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1.1	Intake liner launch review	Participate in launch review for SAGE3 intake liner	Jul 2011
D1.2	Intake liner concept review	Design concept proposals and trade studies. Concept will be chosen at this time.	Sep 2011
D1.3	Intake liner preliminary design review		Jan 2012
D2.1	Intake liner critical design review		May 2012
D2.2	First Article Inspection	Review of manufactured liner hardware at partner's manufacturing facility	Dec 2012
D2.3	Delivery of intake liner test hardware	Test hardware and associated conformance documents.	Dec 2012
D3.1	Support for validation testing	On site or remote support as required	Q1 & Q2 2013
D3.2	Test analysis complete	Report analysing validation data	Q1 2014

4. Topic value (€)

The total value of this work package shall not exceed:

5,000,000 €
[five million euro]

This topic value is a maximum gross value for the work package.

Awards of between 50-75% of this value may be made by the Clean Sky Joint Undertaking.

5. Remarks

Partners are encouraged to propose additional turbofan intake related technologies for validation on the ground engine test.

The dates of the deliverables listed above, other than the FPS dates for test hardware, are preliminary and alternative dates will be considered.

Topic Description

CfP topic number	Title		
JTI-CS-2011-01-SAGE-03-010	**Steel casting process advancement**	Start date	*T0*
		End date	*T0 + 24M or before Oct 2013*

1. Topic Description

Significant reductions in specific fuel consumption, nitrous oxide emissions and noise of large turbofan engines will require developments in lightweight and efficient components and possible changes to the thermodynamic cycle compared with current state of the art engines. Building on technologies developed in existing programmes (including VITAL and NEWAC), the SAGE3 project will demonstrate a number of technologies applicable for large 3-shaft turbofan engines that will reduce weight and improve efficiency.

In order to answer the needs of the SAGE3 project in terms of research, technological development and demonstration activities, it is planned to offer individual tasks to the industry, universities or any legal entity. Therefore, the present Call for Proposal supports the further development of steel investment casting methods to enable lighter weight designs of environment-friendly aero-engine components.

Jet engine components precision cast from steel alloys exists today. However, the application of steel castings is limited due to weight penalties associated with difficulties in casting:

- thin sections below 2mm in thickness
- complex geometries needed for structurally efficient designs including reinforcement webs and hollow sections, where inserts may be needed and inspection may be difficult.
- corrosion and temperature resistant high strength steels which only appears commercially in sheet or forged material forms

This topic description aims at challenging the castability of aerospace steels from two directions:

1. Characterise and challenge the minimum castable wall thickness for the alloy 17-4PH.
2. Explore the castability limits for steel alloys that are not commonly cast today.

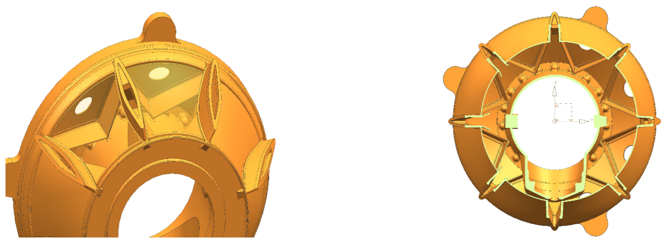


Fig. 1, A generic intermediate compressor case structure designed as a steel casting. Dia: 500 mm

Task 1: Management

Organisation:

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

Time Schedule & Work package Description:

– The partner shall work to the agreed time-schedule (outlined in Part 4) and work package description.

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

Progress Reporting & Reviews:

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

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

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

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

General Requirements:

– The partner shall work to a certified standard process.

Task 2: Minimising castable wall thickness

Characterise and challenge the minimum castable wall thickness for the alloy 17-4PH (AMS 5355) by a design of experiment approach for the investment casting process. Typically this activity is performed in three steps;

1. Simple (specimen type) geometries relevant for the engine component shown in the introduction to this topic description. These specimens are used for exploring one parameter at a time.
2. More complex geometries (still simplified) are then studied to explore the interaction between process parameters.
3. Explore possibilities for post processing the casting for improved quality and/or reducing wall thickness. Typical processes include hot isostatic pressing (HIP) and chemical milling.

It is expected that the Partner will support the three steps above with casting process simulations and scientific metallurgical competence.

Casting quality requirements including defect acceptance criteria, material properties, geometrical dimension and tolerances will be similar to current aero engine practices. More detailed CAD-models and quality requirements will be sent to the CfP applicant after an NDA with Topic Manager has been signed, see remarks section at the end of this topic description.

Task 3: Castability limits for steel alloys that are not commercially cast today

Explore the castability limits for steel alloys with improved mechanical, damage tolerance or corrosion properties that are not commonly cast today. The castability will be explored though lab scale casting trials and material investigations (cut-ups, microscopy and mechanical tests.) The objective is to generate process parameters such that a more realistic, complex engine component can be cast at the end of the project.

At the start of activities Topic Manager will define three commercially available alloys similar in composition to the baseline alloy. The alloy composition may include titanium as a precipitation hardening element which may require a vacuum casting process. The CfP partner and Topic Manager will commonly agree on geometries and test procedures for the initial trials. The partner will procure the material needed for the trails. A test campaign will be performed to define process parameters for a more complex final casting trial. This geometry of the final casting trial will a ring strut ring geometry with some slender stiffening webs preferably in 0.5 m diameter size.

Examples of alloys considered for the casting trials and quality requirements will be sent to the CfP applicant after an NDA with Topic Manager has been signed, see remarks section at the end of this topic description.

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

- The CfP partner needs to master investment casting of complex geometry steel components.
- The CfP partner should have equipment, or an available supply network for vacuum casting and for post processing the casting with for instance HIP (Hot Isostatic Pressing) and chemical milling.
- The CfP partner needs testing and analysis equipment for evaluating the casting trials, or an available supply network. This includes e.g. dimensional control, fluorescent penetrant inspection X-ray, metallography and

mechanical testing according to aerospace standards.

- It is considered beneficial if the CfP has extensive experience in numerical simulation of the casting process.
- Experience in performing applied collaborative industrial research in international environment is considered as essential.

3. Major deliverables and schedule 24 Months

Deliverable	Title	Description (if applicable)	Due date
D1	Detailed Project Plan	Task 1: schedule with milestones,	T0 + 1M
D2	Test plan for Design of Experiments for reduced minimum wall thickness	Task 2	T0 + 3M
D3	Documentation of casting trials including comparison to manufacturing process simulation	Task 2	T0 + 15M
D4	Documentation of results from casting post processing experiments	Task 2	T0 + 24M
D5	Test programme for castability experiments for steel alloys with limited castability	Task 3	T0+3M
D5	Documentation of first batch of casting trials	Task 3	T0 + 12M
D6	Documentation of final casting trial for one steel alloy with limited castability	Task 3	T0+ 24M

4. Topic value (€)

The total value of this work package shall not exceed:

800,000 €

[eight hundred thousand euro]

This topic value is a maximum gross value for the work package.

Awards of between 50-75% of this value may be made by the Clean Sky Joint Undertaking.

5. Remarks

A 1.5 stage proposal process is considered. Organisations interested in this call are encouraged to contact Topic Manager via the Clean Sky Joint Undertaking to sign a non-disclosure agreement, after which specific component geometries and material specifications are to be released. This will help the applicant to make a more specific proposal.

All documents are preferably written in English.

Topic Description

CfP topic number	Title		
JTI-CS-2011-01-SAGE-03-011	**Advanced press forming and hardening of high strength steels**	Start date	*T0*
		End date	*T0 + 24M*

1. Topic Description

Significant reductions in specific fuel consumption, nitrous oxide emissions and noise of large turbofan engines will require developments in lightweight and efficient components and possible changes to the thermodynamic cycle compared with current state of the art engines. Building on technologies developed in existing programmes (including VITAL and NEWAC), the SAGE3 project will demonstrate a number of technologies applicable for large 3-shaft turbofan engines that will reduce weight and improve efficiency.

In order to answer the needs of the SAGE3 project in terms of research, technological development and demonstration activities, it is planned to offer individual tasks to the industry, 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, or part of components, which can be manufactured by a combined press forming and heat treatment process.

The CfP objective is threefold:

- Develop the press forming/hardening technology for aerospace grade steels by adapting the process to existing sheet metal component geometry. Evaluate benefits compared to conventional techniques and adapt and verify manufacturing and material simulation process tools to the aerospace material and to the specific features to enhance the design process.
- Explore the possibility to use a variable sheet thickness in the process.
- Explore if specific design features usually manufactured from forged or cast material can be manufactured by the press forming/hardening technology. Evaluate weight reduction benefits compared to conventional designs

Task 1: Management

Organisation:

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

Time Schedule & Work package Description:

– The partner shall work to the agreed time-schedule (outlined in the Part 4) and work package description.

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

Progress Reporting & Reviews:

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

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

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

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

General Requirements:

– The partner shall work to a certified standard process.

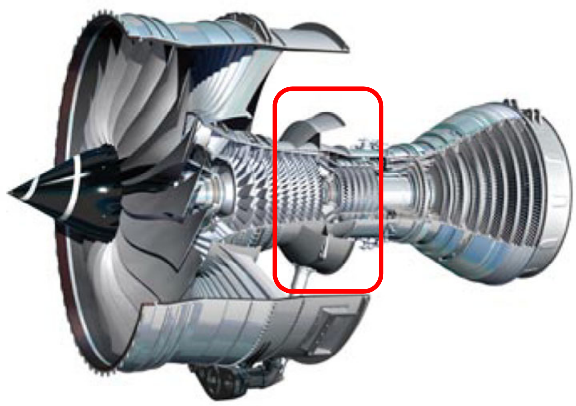
Task 2: Material characterisation of aerospace grade steels

This study aims at exploring the applicability of aerospace grade steels to the press forming/hardening technology. To do so, the possibilities and limitations of the materials need to be thoroughly examined. The partner will perform extensive research on several different material qualities, selected together with Topic Manager. Studies shall include:

- Characterisation of the materials necessary to set press forming/hardening process parameters and to allow numerical simulation of the process.
- Process optimisation with respect to component quality and cost, material properties and formability and tooling wear. This activity is considered to be experimental but supported by FE-based manufacturing process simulation.
- Documentation of material characterization and recommendation of process parameters.

Task 3: Design and Manufacturing

Task thee aims at applying the press forming/hardening technology to the specific component requirements and geometries for a fabricated intermediate compressor case for a three shaft turbofan engine. A fabrication is a weld assembly consisting of sub-components manufactured from cast, forged and formed sheet material.



At least three subcomponents and design features will be explored, developed, manufactured, and tested.

1: A sheet metal disc shaped geometry with formed local features - ~700 mm diameter. This subcomponent is formed by conventional processes today and the intention is to evaluate the benefits of the new process together with the possibilities to start from sheets of non-uniform thickness also considering pre- or post welding and heat treatment.

2: Explore the possibilities to substitute at least two design features made from cast or forged material forms with sheet metal equivalents. This study will start with a selection of interesting design features where both Topic Manager and the CfP partner participate. Proposals are to be developed and analyzed, after which two features are to be selected for manufacturing trials and mechanical testing. Finally a benefits assessment will be performed where material properties, manufacturing robustness, weight and cost are evaluated and compared to the current solutions.

Details of these geometries will be released after signing an NDA with Topic Manager, see remarks section in this topic description.

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

- The CfP partner needs to be equipped with analysis and testing tools necessary to characterise the materials for press forming /hardening. A well developed relationship with university expertise in this field is considered an advantage.
- The CfP partner needs to have extensive experience in numerical simulation of the manufacturing process to a degree where both geometry and material properties can be quantitatively predicted.
- The CfP partner needs to have manufacturing (press forming hardening) equipment available for component manufacturing.
- The CfP partner should be able to perform mechanical testing at sub component level.
- The CfP partner needs to be able to provide (by themselves or by subcontracting) sheet metal with non-uniform thickness.
- Experience in performing applied collaborative industrial research in international environment.

3. Major deliverables and schedule 24 Months

Deliverable	Title	Description (if applicable)	Due date
D1	Detailed Project Plan	Task 1: schedule with milestones, technical specification of simulation process	T0 + 1M
D2	Documentation of material properties necessary for process development	Task 2	T0 + 09M
D3	Documentation of manufacturing process for sheet metal disk including process simulation and benefits analysis	Task 3:1	T0 + 15M
D4	Documentation of manufacturing process for two component features including process simulation and benefits analysis	Task 3:2	T0 + 24M
D5	3D simulation tool Validation	Task 1 & 2	T0 + 24M

4. Topic value (€)

The total value of this work package shall not exceed:

500,000 €

[five hundred thousand euro]

This topic value is a maximum gross value for the work package.

Awards of between 50-75% of this value may be made by the Clean Sky Joint Undertaking.

5. Remarks

A 1.5 stage proposal process is considered.

Organisations interested in this call are encouraged to contact Topic Manager via the Clean Sky Joint Undertaking to sign a non-disclosure agreement after which specific component geometries and material specifications are to be released. This will help the applicant to make a more specific proposal.

All documents are preferably written in English.

Topic Description

CfP topic number	Title		
JTI-CS-2011-01-SAGE-04-008	**Casting process optimization and validation of hollow multivane clusters with thin walls and trailing edges**	Start date	*T0*
		End date	*T0 +18M*

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 development of a casting process for polycrystalline IN713C hollow multi vane cluster (5-7 airfoils) with ambitious wall thickness tolerances. The minimum wall thickness will be 0,5 mm with a wall thickness tolerance of +/-0,25mm. The nominal requirement for the trailing edge thickness is 0,45 mm. In order to achieve these goals, the dimensional requirements for the core supplier have to be tightened, the core support has to be improved and the casting parameters have to be adjusted to avoid mistune or shrink.

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 Topic Manager 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 layed 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 telecon).

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

General Requirements:

– The partner shall work to a certified standard process.

Task 2: Analysis

– The partner shall study and evaluate the given requirements for the hollow Multi Vane Cluster with thin walls to be produced, benchmark the technical choices and select the adequate technology in order to fulfill the given requirements.

– The partner shall evaluate in a first phase which is the better and most suitable approach, giving a solid guideline, to develop the Multi Vane cluster with the given requirements.

– The partner has to evaluate a concept how to position the core during waxinjection and casting

– The partner has to evaluate the dimensional requirements of the core , which are needed to fulfill the task

– The partner has to work out a trial matrix, including the variations of all major parameters

Task 3: Development

– The partner shall design a wax and core tool

– The partner has to procure cores and inspect them for useability

– The partner has to inject waxes and assemble molds with different gating schemes (e.g amount of gates, position, size)

– The partner has to cast the molds with different casting parameters (e.g. wrapping, mold temperature, metal temperature)

– The partner has to inspect the castings especially for wall thickness , misrun and shrink (FPI and X-ray inspection)

It is the decision of the partner how many molds and variations will be used in order to develop a robust process which fulfills the dimensional and metallurgical requirements of the drawing.

Task 4: Validation

– The partner shall perform the necessary testing for prototype validation and optimization.

– The partner shall demonstrate the fulfillment of all requirements by processing 6 ESA molds and present a validation package which contains the inspection results: NDT-results, metallographic results, dimensional results

– The partner shall produce further molds, which will be machined at MTU in order to check the metallurgical soundness after machining and to perform an engine test (one set of engine suitable hardware for testing).

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

- skills of the workers, also from Engineering and Quality, have to be on a high level
- experience in vacuum casting business is mandatory
- ISO9001 and 9100 approvals

The manufacturing of such a hollow multi vane cluster first of all requires capable equipment on the shop floor, e.g:

- Metallurgical lab for cut up preparation and inspection
- NADCAP approved NDT- processes
- equipment to perform a dimensional inspection of cores
- Wax Presses
- Dipping tanks, sanding stations, drying rooms
- Vacuum casting furnace
- core leaching device

Also different NDT inspections are required, e.g:

- FPI
- X-ray
- wallthickness inspection
- CMM

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D0	Technical specification sheet	schedule with milestones, detailed technical deliverables checked in reviews	T0 + 1M
D2	Inspection report of wax and core tool and Start Development trials		T0 + 4M
D3	Development trial report and Start ESA trial		T0 + 10M
D4	Start ESA confirmation trial		T0 + 13M
D5	Provide ESA hardware (parts out of 6 ESA molds) and ESA documentation Provide one set of engine suitable hardware for testing		T0 + 18M

4. Topic value (€)

The total value of this work package shall not exceed:

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

If applicable

Topic Description

CfP topic number	Title		
JTI-CS-2011-01-SAGE-04-009	**Integrating forging- and process-simulation into SAGE4 GTF LPT rotor design**	Start date	*T0*
		End date	*T0+30M*

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 GTF 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 an integrated, functional, variability-based and simulation-based design chain with a high optimization potential to allow alternate designs of environment-friendly aero-engine components, fabricated by means of optimized closed-die forging and heat treatment processes for rotor disks to account for high reliability, safety and function-to-weight ratio. This proposal focuses on the design of a SAGE4 engine low pressure turbine disk of the direct aged (DA) nickel based superalloy DA 718 material.

Due to extremely high requirements with respect to strength, weight and safety the design of aero-engine turbine disks is an elaborate task living from a mature design experience by several specialists within different disciplines at the engine manufacturer as well as the forging company. Future engine design drives structural design to the limit and calls to minimize integrity and safety margins. To account for this claim sophisticated computational methods and simulation-based design is state-of-the-art at both the engine manufacturer and the raw part supplier.

However, the integration of different computational results within an interdisciplinary and intercompany design-chain is not yet established. The interaction between each design responsibility represents nowadays a challenging task and interdisciplinary optimization of the final product is difficult to achieve. To enable such optimization the present *Call for Proposal* is aimed to provide the necessary information exchange based on virtual design methods.

A successful design chain allows the next step in optimizing rotor disks with respect to reliability, safety and function-to-weight ratio. For instance the prediction of material variability due to micro-structural anomalies or the tracking of hazardous material defects along the whole product chain improves rotor design with respect to structural integrity. A link to ultrasonic (US) inspection simulation is an additional requirement to allow for the minimization in margins whilst maintaining the risk levels to the acceptable standards of the certifying authorities.

The setup of such a design-chain requires a well-defined interface to exchange simulation results. In addition it requires a well-defined problem description for each computational modelling task, the organisation of data responsibilities, a thorough declaration of accuracy with respect to the model itself and the numerical results and finally a clear and well-defined communication between the engine manufacturer and the forging company. Moreover, each individual partner has to bring in a sophisticated computational modelling capability and the necessary experience to evaluate and validate the models and results.

On the forging companies side this requires the following computational design aspects, specified to the application of nickel-based DA (direct aged) 718 turbine disk forgings:

Requirement 1: Established computational prediction of the forging process

Software packages based on Finite Element Methods are typically used to predict form filling, deformation and temperature during the whole forging and heat treatment process. This simulation builds the fundament of subsequent computational models and is therefore required to meet a high reliability. Forging process parameters, boundary conditions and material models have to be taken into account. Experimental validation is required to prove the model to a specified accuracy. The applicant has to prove excellent experience in such computational modelling, model evaluation and experimental substantiation.

Requirement 2: Micro-structural modelling of nickel-based super-alloys

The specific micro structure determines the majority of functional properties required by the rotor design. It is therefore beneficial for the design process to predict micro-structural properties such as grain size and grain growth during the forging and heat treatment process and across the individual part section. The applicant is required to provide a physically based computational model to predict grain size and growth due to static, dynamic and meta-dynamic recrystallization for nickel-based super-alloys. Experience with physically motivated modelling of micro-structure is required to extend such models to more complex phenomena like the direct aging process.

Requirement 3: Modelling of material properties (yield strength, fatigue, creep) relevant for structural rotor design

The goal of rotor design at the engine manufacturer is to meet the requirements with respect to structural integrity, lifetime, weight, etc. The design methods thus rely on the prediction of material properties such as yield strength, low/high cycle fatigue and creep which correlate with the materials' micro-structure resulting from forging and heat treatment. Within this project an advanced physically motivated computational modelling approach is envisioned to predict these functional properties and their variability. The applicant has to provide experience in developing such models.

Requirement 4: Provision of simulation results relevant for ultra-sonic inspection prediction

Another design aspect is the ultrasonic (US) inspection capability of a specific rotor structure. Following the goal of a fully integrated simulation-based design it is required to provide a suitable approach to plug relevant simulation results into the envisioned interface to allow simulation-based prediction of US inspection capability and accuracy (e.g. signal-to-noise-ratio).

Requirement 5: Accuracy evaluation based on state-of-the-art statistical methods

Due to variability in experimental input data, process boundary conditions, model non-linearity and physical complexity the envisioned integrated design approach is inevitably probabilistic in nature. It is thus of exceptional importance to address the accuracy and robustness of the simulation chain and every involved member. It is therefore required to take the variability into account via sophisticated computational statistical methods. The applicant needs to provide experience in this field and prove statistical significance of all relevant input data and experimental substantiation.

Requirement 6: Collaboration with raw material supplier

A number of functional properties of a turbine engine disk are related already to the very early production stage, i.e. the ingot. To close the design-chain it is envisioned within this project to track the full history of the final rotor disk by simulation models. It is therefore required for the applicant to establish a close collaboration with their supplier.

Task 1: Management

Organisation:

– The partner shall nominate a team dedicated to the project and should inform Topic Manager 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 Topic Manager facility.

General Requirements:

– The partner shall work to a certified standard process.

Task 2: Report on the quality of existing computational models

Preliminary to integrating computational models the applicant has to evaluate his applied and established computational models (forging simulation, micro-structure model, model for functional properties). This should include an assessment of the physical motivation of the models. Additionally, a quantification of variation in functional results with respect to input parameters, boundary conditions, simulation work-flow is requested. Finally, experimental validation where applicable, specification of the respective database and evaluation on statistical significance needs to be reported.

Task 3: Plan how to develop a physically motivated computational model to predict functional properties

The functional properties yield strength, low/high cycle fatigue and creep are fundamental for the design of a rotor. The applicant is requested to provide a conceptual plan how to predict these properties with a physically motivated computational model. A risk assessment on the accuracy of the respective model is to be reported. Potential experimental substantiation needs to be addressed.

Task 4: Development of well-defined interface for all relevant data exchange

The interface for a integrated design chain has to be developed in close collaboration with the engine manufacturer. A suitable interface needs to be defined to allow collaboration on simulation results with its evaluation and interpretation. This includes the definition of data formats, development and evaluation of suitable data postprocessing methods and tools. In addition an exchange of relevant input data and boundary conditions for the individual simulations must be established since this information is key for a functional and goal oriented evaluation of simulation results. The issue of proprietary of specific data needs to be addressed. For all exchange of results a quantitative evaluation of variability and accuracy must be provided and linked to the simulation data.

Technically, the interface should be realized by selecting and eventually adapting a suitable postprocessing software which is able to display various simulation results. Moreover, a databank system needs to be developed to handle and store the diverse result files, backgorund information, statistical analyses, etc.

Together with the interface a suitable work-flow for the integrated design approach has to be defined in collaboration with the engine manufacturer. Milestones have to be defined when and which simulation data is to be exchanged. A way to handle responsibilities for simulation and results has to be developed.

Task 5 : Plug-in of necessary input-data to the integrated simulation-based design chain

The supplier has to provide the necessary data in the specified format (cf. task 2) to accomplish the integrated design approach. This includes the US inspection aspect where the prediction of an optimal inspection strategy (e.g. signal-to-noise level) based on the simulation results is established.

Task 6 : Realization of integrated design approach in cooperation with engine manufacturer to design an advanced turbine disk stage for the SAGE4 geared turbofan

For the specific engine program of a SAGE4 geared turbofan demonstrator the integrated design approch should be realized. Assuming that the engine manufacturer fulfills its part of the design chain the supplier has to provide necessary input and to fulfill his design role.

Task 7 : Manufacturing of turbine disk and experimental validation of integrated design approach

Based on the new design a SAGE4 engine turbine disk is manufactured. Before or after the engine run a reasonable experimental validation of the predicted properties will be conducted and potential variation will be evaluated and reported.

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

- Topic Manager approved supplier for class 1 (critical) parts (i.e. forgings for turbine engine rotating disks). - 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 (if applicable)	Due date
D1	Detailed Project Plan		T0 + 1M
D2	Report on the quality of existing computational models		T0 + 6M
D3	Plan how to develop a physically motivated computational model to predict functional properties		T0 + 6M
D4	Simulation Interface		T0 + 12M
D5	Realized integrated design for a turbine disk for the SAGE4 demonstrator programme		T0 + 18M
D6	Hardware (disk forging) for SAGE4 demonstrator		T0 + 24M
D5	Experimental validation of simulation-based design		T0 + 30M

4. Topic value (€)

The total value of this work package shall not exceed:

400,000 €

[four 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

If applicable

Topic Description

CfP topic number	Title		
JTI-CS-2011-01-SAGE-04-010	**Total Measurement System for Geometry and Surface Inspection of bladed Disks (TOMMI)**	**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 GTF 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 inspection methods with a high optimization potential to allow alternate designs of environment-friendly aero-engine components.

The demand for BLISKs (bladed disks) is strongly increasing, presumably by a factor 4 to 6 in the next 7 years. This growth will also be mirrored in the operating expense for measuring and inspection for BLISKs. Also the increasing complexity of aero engine parts, especially those coming from modern 3D aerodynamics and small tolerances, demand an adequate response in the measuring technique for such parts. At the same time, we also expect a deficiency of well trained inspectors for this time period, thus automated procedures for measurement and inspection is mandatory.

Since nowadays, aero engine parts are produced at different places and countries, the inspection and measuring of such parts have to be done in an unified way to ensure homogeneity in the evaluation of the parts. The best way to assure this, it is to automatise such processes.

Up to now, aero engine parts measurement and inspection procedures are done separately because of the insufficient and/or costly techniques available. First the simple accessible geometric data were acquired, second more specific geometric feature are measured and third a visual and tactile inspection took place for scratches, dip etc. All these steps should be comprised automatically in a measurement – inspection system.

The following list of requirements has to be fulfilled by the measurement – inspection system developed within this frame work.

Requirement 1: CMM is the base technology

Due to the great experience of tactile measurement devices (CMM = Coordinate measuring machine) CMM – machines should be the basic technology for the measurement – inspection System. Other techniques like optical sensors should be implemented in these CMM frame work.

Requirement 2: automated handling system

The geometric feature has to be grabbed in a 3d manner with a precision up to 0.005 mm. The whole surface of the part has to be measured. This requires also sophisticated handling facilities, e.g. robotic systems.

Requirement 3: partial automated generation of measuring program

The strategy to measure Blisks has to be generated partial automatically for time saving reasons (The BLISKs diameters range from 350 mm to 900 mm). Since this demand is very ambitious and challenging, it is not expected a fully automated system during the length of this CLEAN SKY project. But a thoroughly designed concept with measuring components, which have a high degree of technological readiness, is expected.

Requirement 4: Automated visual inspection

Irregularities like scratches, dips etc. have to be detected automatically. The dimensions of such irregularities are 0.1 mm lateral and 0.02 mm in depth. A list of irregularities, specific to the blisk, will be provided by the measurement task owner in every special case.

Requirement 5: Capability of design and building of complex measurement systems

The measurement system has to be designed and build by the applicant. The blisk has to taken from a entry desk and put into the measurement system automatically.
The geometric data e.g. as CAD data will be partial automatically transferred in a measuring program.
The measurement and visual inspection will be performed totally automatically.

Requirement 6: Time and space constraints

The measurement of a BLISK, which includes measurement visual inspection and documentation should not need more than 6 to 8 hours. This is very ambitious. Also the space for the measurement cell should not be much greater than that of a CMM – room.

Requirement 7: Measurement system compliant to international specifications

The measurement equipment and the documentation of the measurement result has to be compliant to international specifications. The comparability to other measurement systems and to national standards (PTB, Germany) has to be guaranteed.

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

Task 1: Management

Organisation:

– The partner shall nominate a team dedicated to the project and should inform Topic Manager 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 Topic Manager facility.

General Requirements:

– The partner shall work to a certified standard process.

Task 2: Analysis

– The partner shall study and evaluate the given requirements for the measurement – inspection system, benchmark the technical choices and select the adequate technology in order to fulfil the given requirements.

– The partner shall demonstrate in a first phase which is the better and most suitable approach, giving a solid guideline, to develop the measurement – inspection system with the given requirements.

Task 3: Development

– The partner shall construct a prototype of a measurement – inspection system which fulfils all mentioned requirements.

Task 4: Validation

– The partner shall perform the necessary testing for prototype validation and optimization.

– The partner shall demonstrate the fulfilment of all requirements.

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

The applicant has to be a producer of coordinate measuring machines, who will develop the above mentioned techniques and implement them in commercial available machines.

Thus the applicant should have:

– At least several years experience in the development and production of coordinate measuring machines

– At least several years experience in the development and production of tactile and optical probes

– Experience in the aerospace market, ideally with coordinate measuring machines applied to aero engine components for some years at companies within the aerospace industry

– ISO 9001 certification covering the development, production and service of coordinate measuring machines

– Sufficient R&D resources and competence to enable the development of the deliverables, including mechanics, optics, software and process development

– Capability to ensure reliable availability of measuring systems in production following the successful end of the development project, including sales and service organization in all relevant regions worldwide, adequate financial resources, and necessary IP rights

– Experience in implementation of third party products like optical probes and robotic systems

– Since there are measurement positions at BLISKs which are difficult to access (till now imprints are used) the applicant should be able to design or should have a small 3d-measurement device to get such an access.

– Ideally experience in collaborative R&D projects

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	Common geometry measurement	Common geometries are defined and automated measured	T0 + 6M
D3	Special geometry measurement	Special geometries e.g. curved edges are defined and automated measured	T0 + 22M
D4	Automated Visual inspection	Irregularities e.g. scratches, dips are defined and automated detected and qualified	T0 + 22M
D5	Automated handling system	A blisk can be handled according to the measurement and inspection requirements	T0 + 22M
D6	Blisk airfoil prototype measurement system	First prototype for airfoil inspection for Demo Hardware	T0 + 22M
D7	Blisk prototype measurement system	More than 80% of the measurements and inspections are done in one system automatically	T0 + 30M
D8	Automatic generation of the measurement program	Based on digital available geometry data e.g. CAD data the measuring program is generated	T0 + 30M
D9	Documentation of measurements	All measurement results are documented according MTU specifications and automatically evaluated	T0 + 30M
D10	Final prototype measurement system	The measuring and inspection program is automatically generated. All measurements, inspections and documentations are done in one system automatically.	T0 + 36M

4. Topic value (€)

The total value of this work package shall not exceed:

1,300,000 €

[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.

5. Remarks

If applicable

Topic Description

CfP topic number	Title		
JTI-CS-2011-01-SAGE-04-011	**Implementation of Carbon-Nanotube Reinforced Aluminium for Aerospace Heat Exchanger Applications**	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 GTF 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 environment-friendly aero-engine components.

Aircraft gas turbine engines have an eternal need for lightweight materials. There is a burgeoning interest in the GTF due to significant reduction in fuel consumption and noise compared to the conventional turbo fan engines. One of the limitations of the geared turbofan engine is that it generates more heat than direct drive turbofans. This heat needs to be dissipated via aluminium air-oil heat exchangers. Constructing these heat exchangers from a higher strength alloy could lead to significant weight reduction. Lower weight structures reduce fuel burn, which in turn reduces CO2 emissions. Recent breakthroughs in nanomaterials have resulted in composite alloys that exhibit the density of aluminium and the strength of steel. Carbon-nanotube (CNT) reinforced aluminium composite has emerged as an important class of material with unique combination of properties that are suitable for heat exchanger application. Carbon-nanotube reinforced aluminium has higher strength, modulus and thermal conductivity at considerably lower density than other aluminium alloys. In addition, this material has excellent high temperature strength compared to other aluminium alloys.

The objective of this project is to demonstrate that CNT-reinforced aluminum can be incorporated into a lightweight heat exchanger and operated in a gas turbine engine environment. The heat exchanger may be fully or partially constructed of the CNT-reinforced aluminum material. The following tasks would be performed in order to assure success:

Task 1: Management

Organisation:

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

General Requirements:

– The partner shall work to a certified standard process.

Task 2: Evaluate material properties and conduct manufacturing trials

The partner company will work with the supplier of the advanced CNT-reinforced aluminium to evaluate feasibility of the material for heat exchanger applications. Additional material characterization may be required, and this work may be subcontracted if neither the partner company nor the material supplier have the requisite testing facilities. Joining trials (welding, brazing, etc.) should also be conducted to determine the optimum method for assembling the heat exchanger.

This task will be considered as a possible exit criteria for the program if the properties of the CNT-reinforced aluminum do not meet the requirements for heat exchanger design.

Task 3: Design & optimization of a core mounted light-weight material compact heat exchanger

The heat exchanger partner should use their validated design tools, including CFD and finite element analysis (FEA) if appropriate, to design a compact heat exchanger that meets heat transfer and pressure drop requirements at a lower total weight than the baseline geared turbofan air-oil cooler.

Major design parameters are given here; additional proprietary specifications will be supplied prior to the design phase:

a. Maximum temperatures

   Max oil inlet temperature limit 205°C

b. Maximum pressures

   The maximum working oil inlet pressure 4500 kPa

   Proof Pressure (no leak or deformation) = 1.5X max working pressure

   Burst Pressure (no fracture) = 2.0X max working pressure

c. Cyclic testing over 500 hours and 2000 pressure cycles

d. The heat exchanger shall be designed with air side hail fins to protect the heat transfer fins from damage during operation.

e. The heat exchanger shall be capable of withstanding damage from high-velocity hailstones, per published aviation safety regulations.

Task 4: Fabrication and validation of light-weight material compact heat exchanger

The partner will fabricate at least two full size heat exchangers for validation activities. One will be used for the bench tests detailed below. Since the burst test will likely render the unit inoperable for engine operation, the second unit will undergo a manufacturer-specified acceptance test procedure and will then be delivered to Topic Manager for engine testing.

The partner must provide heat exchanger validation plan including all partner rig validation and the tests/measurements requested on the engine demonstrator.

Prior to engine running, the following tests are required and are the responsibility of the heat exchanger partner:

a. Burst & proof pressure tests

b. Cyclic pressure test

c. Vibration test

d. Performance Evaluation including

   Air heat transfer coefficient times area (hA) vs. flow tables

   Number of Transfer Units (NTU)-effectiveness table

   Oil and air pressure drop versus flow characteristics

- Provide appropriate conformance documents with the test article.

- Support the geared turbofan demonstrator engine test, including installation of the heat exchanger and instrumentation checkout.

- Analyze both rig and engine test data and provide validation reports to obtain TRL6.

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

The applicant has to demonstrate prior experience in the design, development and manufacture of air-oil heat exchangers for aerospace applications.

The applicant should have:

- Demonstrated experience in technology maturation to higher TRL
- Ability to conduct burst & proof pressure tests
- Ability to perform cyclic pressure test
- Ability to perform vibration test
- Ability to map the performance of a heat exchanger in a bench test environment.

See "Section 5: Remarks" for additional requirements related to the carbon-nanotube aluminum material.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Detailed project plan	Schedule with milestones	T0+1M
D2	Evaluation of viability of CNT-reinforced Al properties for HX applications	Stage gate – proceed only if material properties are determined to be acceptable	T0+6M
D3	HX detailed design report	Report to contain detailed drawings, predicted performance, and results of any analisis performed during the design process.	T0+12M
D4	HX bench test report	Stage gate – proceed only if bench test results meet engine requirements	T0+20M
D5	Delivery of hardware to engine test	Delivery of one HX to MTU for installation on geared turbofan engine	T0+22M
D6	Test Report	To be written following completion of engine testing. Contains test data, details from post-test inspection of hardware, and lessons learned.	T0+28M

4. Topic value (€)

The total value of this work package shall not exceed:

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

Heat exchanger companies who reply to this call for proposal are encouraged to partner with a manufacturer of carbon-nanotube reinforced aluminium. If a partnering arrangement is not feasible, then the heat exchanger company must demonstrate sufficient knowledge of the advanced aluminium's material properties, and also their ability to procure sufficient raw materials to fabricate the heat exchanger(s) for this demonstration.

Topic Description

CfP topic number	Title		
JTI-CS-2011-01-SAGE-04-012	**Electric Smart Engine Actuator**	Start date	*T0*
		End date	*T0+28M*

1. Topic Description

The SAGE4 project intends to develop then demonstrate technologies that will reduce the amount of fuel burned and emissions produced by large, high bypass geared turbofan engines, thereby helping to reduce the environmental impact of aviation. In order to realize dramatic improvements in the aforementioned metrics, future engine designs are trending towards increasingly larger low-speed fans and smaller diameter engine cores. In order to obtain the efficiencies required for the small cores, operating pressures and temperatures are being raised significantly. The thermal loads produced by modern gas turbine engines have and will continue to increase significantly. Due to more integrated engine packaging schemes, it is becoming much more difficult to dispose of the heat load in flight; thermal management has become a serious problem with the potential to limit future engine implementations.

One way to address the thermal load problem is to reduce the amount of heat generated by the propulsion system. Much of the heat generated by the engine core is dumped into the core exhaust. However, a significant amount of heat generated by a modern gas turbine engine is produced by the various external components used to actuate the engine. Conventional actuators are generally either hydraulically or fuel-draulically powered, typically driven via pumps constantly supplying fuel or hydraulic flow, whether it is needed or not.

The Aerospace and related industries are moving towards more on-demand actuation systems. Variable fuel and/or hydraulic pumps are being developed that provide flow and hydraulic power only to the level required at any instant of time. An attractive alternative is to move from fluid to electric power transfer. Electrical power is easily modulated and re-allocated to the various actuator devices around the engine. The overall reliability and safety of the engine can be improved - and its weight and cost reduced - by replacing the pumps, tanks, heat exchangers, plumbing with electrical components and wiring in more / all electric engine architectures.

With more/all electric systems, there is an opportunity for upgradability / reconfigurability that doesn't exist for fluid powered actuation system. Whereas fueldraulic / hydraulic systems utilize plumbing configurations for specific size actuators mounted in specific locations on the engine, electric actuation systems can be reconfigured via a less difficult wiring harness change. The major obstacle to rapid and low-cost reconfiguration of electric actuation systems is the need to modify and re-certify the power electronics in the Engine Controller which sends commands to the actuator(s).

One solution that is rapidly gaining support is the idea of a "Smart" Electric Actuator - one in which all of the Power electronics and Analogue circuitry are located next to or even in the actuator itself. An on-engine electrical distribution network allows actuators to be "plugged in" to provide power. A digital communication network provides commands to and receives feedback and health information from each of the actuators. All of the analogue-to-digital and digital-to-analogue conversion, feedback signal conditioning, loop closure and basic health assessment occur at the actuator itself, with only digital data shared with the Engine Controller.

The objective of this task is then to evaluate via demonstration the operation of an Electric Smart Actuator in a gas turbine engine, in an inlet guide vane or stator vane application. The actuator should require little or no dedicated cooling, and should incorporate any necessary control and power electronics. A partner company(s) would be responsible for developing the actuator hardware for the test to requirements provided them by Topic Manager. Bench testing of the actuator would be required prior to installation on the engine. The understanding gained through this project will identify the technology-gaps relative to delivering Smart Electric Actuators capable of operating on the core-mounted environment of an aero gas turbine, providing direction / focus of follow-on research efforts.

Specific Requirements:

Actuator Mechanical Requirements:

Position accuracy:	0.2 % full scale Accuracy to include hysteresis shall be minimized.
Stroke:	63.5 to 88.9 millimeters
Stroke adjustment:	+/- 32 millimeters
Slew rate:	56 millimeters per second, minimum Measured at the drive pin
Actuator Load:	+/- 16000 N @ slew rate
Typical holding load:	+/- 1800 N
Surge load:	22500 N, less than 0.08 seconds

Actuator must survive surge with limited (less than 10% stroke) or no run back and with no damage.

Mounting & Environmental Requirements:

Fireproof:	Unit shall meet FAR/JAR fire standards.
Weight Goal:	Less than 4.0 kg
Temperature environment:	-18 to 160 ^{o}C
Vibration:	15 g
Mounting:	Unit shall be engine case mounted
Cooling:	Unit shall not require dedicated cooling.

Actuator Motor and Controller:

DC Link voltage (nominal):	270 VDC
Position feedback accuracy:	0.1% of full stroke
Test communications:	UART, RS232/422 format
System Communications:	CAN communications shall be used for the engine testing.
Number of channels:	Controller shall have a single channel.
Data link:	Controller serial data link is ETHERNET.

Major design parameters are given here; additional proprietary specifications will be supplied prior to the design phase.

Task 1: Management

Organisation:

– The partner shall nominate a team dedicated to the project and should inform Topic Manager 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 Topic Manager), 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 Topic Manager Facility.

General Requirements:

– The partner shall work to a certified standard process.

Task 2 : Preliminary Smart Electric Actuator Design

Work with electronic component suppliers to determine the current state-of-the-art in both Power and

Control electronics capability for harsh environment applications, based on the requirements listed above. Based on currently available power/control electronics, downselect a candidate actuator application for detailed design, manufacture and test as a Smart Electric Actuator. Criteria would include the ability of Smart Electronics to survive the anticipated temperatures, thermal cycles and vibration at the location selected, being mindful of the expected duration of testing (i.e. actuator does not need to be full-life).

Task 3 : Detailed Smart Electric Actuator Design

Design a Smart Electric Actuator based on the Requirements provided, using the Criteria identified in Task 2. Consider electrical power and digital communication interface, mechanical packaging for volume, cost and weight, and thermal factors that would ensure such an actuator could survive full life

Task 4 : Smart Electric Actuator Manufacture

Manufacture of the Smart Electric Actuator design derived in Task 3.

Task 5 : Smart Electric Actuator 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 Smart Electric Actuator in a bench environment to validate performance and durability
- Deliver actuator to MTU for testing in the geared turbofan engine demonstration
- Report results of testing

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

-The partner must have experience in the design, fabrication, and testing of aerospace actuators.
- Prior experience in the design, fabrication, and testing of electric actuators is strongly recommended.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Detailed project plan	Schedule with milestones	T0+1M
D2	Preliminary Smart Electric Actuator Design Report	Present one or more potential actuator concepts for review and approval	T0+8M
D3	Detailed Smart Electric Actuator Design Report	Report to contain detailed drawings, predicted performance, and results of any analysis performed during the design process.	T0+16M
D4	Manufacture Prototype Release Report	Results of bench testing and verification that the prototype actuator will meet engine test requirements	T0+22M
D5	Smart Electric Actuator Test Report	A report providing an overview of: -How the Smart Electric Actuator performed - Recommended further testing supporting TRL progression -Recommended changes for next iteration	T0+28M

4. Topic value (€)

The total value of this work package shall not exceed:

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

If applicable

Topic Description

CfP topic number	Title		
JTI-CS-2011-01-SAGE-04-013	**High temperature Ni-based alloy forging process advancement**	Start date	*T0*
		End date	*T0 + 24M*

1. Topic Description

Significant reductions in specific fuel consumption, nitrous oxide emissions and noise of geared turbofan engines will require developments in lightweight and efficient components and possible changes to the thermodynamic cycle compared with current state of the art engines. Building on technologies developed in existing programmes (VITAL and NEWAC), the SAGE 4 project will demonstrate a number of technologies applicable for geared turbofan engines that will reduce weight and improve efficiency.

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 high temperature Ni-based alloy forging process advancement to enable lighter weight designs of environment-friendly aero-engine structural components.

Figure 1. Example of welded Turbine Exhaust Case including forged parts

Jet engine components made of Ni-based alloys exist today. The alloy IN718 is widely used for casings, structures as well as rotating parts such as discs. Recently several new alloys for temperatures above the limit of IN718 have been developed, such as for example Allvac 718+, H282. Also the more commonly used alloys Waspaloy and Nimonic 263 could be of interest. These alloys do not have the drawback of poor weldability of other high temperature alloys.

This research topic aims at improving the understanding of forging, residual stresses and deformation of the forgings intended for fabricated aeroengine structures, such as turbine exhaust cases. This can be achieved through:

-Billet conversion studies using radial forging

-Controlled die forging experiments

-Generation of material property data for forging simulation

-Simulation of residual stresses and distortion after thermomechanical treatment using FEM-methods.

-Measurement of residual stresses in forged nickel base parts using advanced neutron scattering techniques.

-Mechanical testing of the forged material

At the start of activities Topic Manager will define two alloys similar in composition to the baseline alloy. Raw material procurement is expected to be included in the scope of this work.

The CfP partner and Topic Manager will commonly agree on geometries and test procedures for the initial forging trials. A test campaign will be performed to define process parameters for a more complex final net shape forging.

Examples of alloys considered for the forging trials, as well as more detailed CAD-models and quality requirements will be sent to the CfP applicant after an NDA with Topic Manager has been signed, see remarks section at the end of this topic description

Task 1: Management

Organisation:

– The partner shall nominate a team dedicated to the project and should inform Topic Manager Corporation project manager/CfP 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 Topic Manager), Engineering & Quality.

Time Schedule & Work package Description:

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

– Both, the time-schedule and the work package description laid out in this Call shall be further detailed as required and agreed in 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 work packages, technical achievement, time schedule, potential risks and proposal for risk mitigation.

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

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

– The review meetings shall be held quarterly by WEBEX or at Topic Manager Corporation.

General Requirements:

– The partner shall work to a certified standard process.

Task 2 Billet conversion studies

Billet conversion using radial forging should be studied. This method is expected to yield better mechanical properties, a more fine-grained microstructure and improved non-destructive inspectability.

Task 3: Forging trials

Controlled die forging experiments of a specified geometry and parts for verification of simulations should be performed.

Improvement of the forging processes based on the forging experiments should be made.

Forgings for the final Turbine Exhaust Case demonstrator parts should be produced.

Mechanical testing of forged material should be performed.

Task 4: Material property generation and forging simulation

Generation of material property data, such as flow stress data for creep, thermophysical data, elastic data, etc should be carried out.

Simulation of residual stresses and distortion after thermomechanical treatment using FEM-methods will be performed.

The data exchange format (stress, temperature) for exchange between the partner and Topic Manager needs to be defined. The idea is that Topic Manager will use predicted residual stresses from the forging process in simulation of the following manufacturing steps (welding, heat treatment)

Task 5: Measurement of residual stresses in forgings

Verification of the forging simulation will be performed by measurement of residual stress. Measurement of residual stresses in forged nickel base casings (incl. process variation) using advanced neutron scattering techniques is envisaged.

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

- Radial forging equipment for billet conversion
- The CfP partner needs to master die forging of near net shape Ni-base alloy parts.
- The CfP partner needs testing and analysis equipment for evaluating the forging trials, or an available supply network. This includes e.g. dimensional control, ultrasonic inspection..........
- The CfP partner should have extensive experience in FEM simulation of the forging process.
- The Cfp partner or an available supply network should be able to measure residual stresses by advanced neutron scattering techniques
- Experience in performing applied collaborative industrial research in international environment is considered as essential
- For this topic a cluster of one commercial forge and one or several institutes/universities could be considered.

3. Major deliverables and schedule 24 Months

Deliverable	Title	Description (if applicable)	Due date
D1	Detailed Project Plan	Task 1: schedule with milestones,	T0 + 1M
D2	Test plan for Design of Experiments for billet conversion studies	Task 2	T0 + 3M
D3	Test plan for Design of Experiments for reduced residual stresses.	Task 2-3	T0 + 3M
D4	Documentation of billet conversion tests	Task 2	T0+12M
D5	Documentation of forging trials including comparison to manufacturing process simulation	Task 3	T0 + 24M
D6	Documentation of forging simulation results, including mechanical properties generated.	Task 4	T0 + 18M
D7	Documentation of residual stress measurements	Task 5	T0+24M

4. Topic value (€)

The total value of this work package shall not exceed:

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 1.5 stage proposal process is considered. Organisations interested in this call are encouraged to contact Topic Manager to sign a non-disclosure agreement after which specific component geometries and material specifications are to be released. This will help the applicant to make a more specific proposal.

Raw material procurement is expected to be included in the scope of this work

All documents need to be written in English.

Topic Description

CfP topic number	Title		
JTI-CS-2011-01-SAGE-04-014	**High temperature Ni-based super alloy casting process advancement**	Start date	*T0*
		End date	*T0 + 24M*

1. Topic Description

Significant reductions in specific fuel consumption, nitrous oxide emissions and noise of geared turbofan engines will require developments in lightweight and efficient components and possible changes to the thermodynamic cycle compared with current state of the art engines. Building on technologies developed in existing programmes (VITAL and NEWAC), the SAGE 4 project will demonstrate a number of technologies applicable for geared turbofan engines that will reduce weight and improve efficiency.

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 Ni-based alloy investment casting methods to enable lighter weight designs of environment-friendly aero-engine components.

Jet engine structural components cast from Ni-based alloys, such as IN718 exist today. However, the next generation of engines require structural components operating at 100-150°C higher temperatures than possible with IN 718. Alloys of interest for structural components in this temperature range are for example Allvac 718+, Haynes 282, Nimonic C263, Waspaloy. These alloys have primarily been developed in wrought form. The purpose of this study is to establish and improve castability and weldability for a selection of these alloys.

This research topic description aims at investigating the castability of high temperature alloys. We expect the partner to define in more detail and execute the experiments necessary to get a good understanding of the castability.

Some suggested elements of the study could be:

1. To perform casting process simulation to direct the experimental activities and help in interpretation of experimental results.
2. To experimentally explore castability limits for Ni alloys that are not commonly cast today.
3. To challenge the minimum castable wall thickness and cast thin sections below 2 mm in thickness.
4. To study castability as a function of varying alloy composition from a nominal composition.
5. To vary the casting parameter and post casting thermal treatment and study the effect on weldability.
6. To cast component-like geometries (see figure 1)

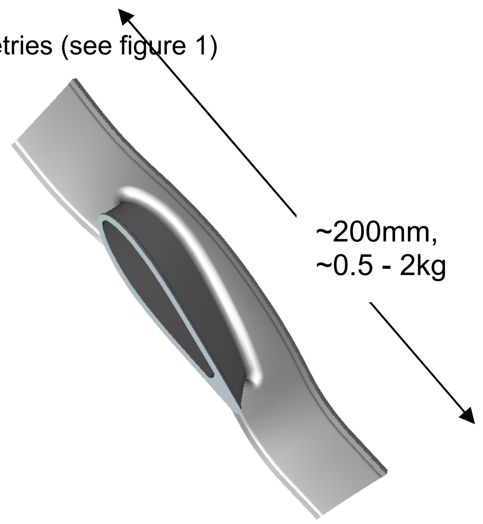


Figure 1.Simplified geometry for casting trials for sub-assembly of welded Turbine Exhaust Case

Task 1: Management

Organisation:

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

Time Schedule & Work package Description:

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

– Both, the time-schedule and the work package description laid out in this Call shall be further detailed as required and agreed in 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 work packages, technical achievement, time schedule, potential risks and proposal for risk mitigation.

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

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

– The review meetings shall be held quarterly by WEBEX or at Topic Manager Corporation.

General Requirements:

– The partner shall work to a certified standard process.

Task 2: Castability limits for Ni alloys that are not commercially cast today

Explore the castability limits for one Ni alloy (using IN718 as refererence) with improved mechanical properties at temperatures 150°C higher than IN718, that is not commonly cast today. The castability will be explored through lab scale casting trials and material investigations (cut-ups, microscopy and mechanical tests). The objective is to generate process parameters such that a more realistic, complex engine component can be cast at the end of the project.

At the start of activities Topic Manager Corporation will define the alloy. The CfP partner and Topic Manager will commonly agree on geometries and test procedures for the initial casting trials. A test campaign will be performed to define process parameters for a more complex final casting trial. This geometry of final casting trial will be the geometry in figure 1 or possibly a similar geometry with more design features included as for instance bosses, flanges or reinforcements.

Task 3: Minimum castable wall thickness

Challenge the minimum castable wall thickness for the Ni based alloy selected by a design of experiment approach around a given component geometry for the investment casting process (including design changes negotiated with Topic Manager) and by exploring possibilities for post processing the casting for improved quality or reducing wall thickness.

Casting simulation could be used as part of the castability study.

The component geometry will be a part of a welded turbine exhaust case structure for turbofan engines. The part will weigh less than 3 kg. Casting quality requirements will be derived from geometrical and material properties needed for future efficient engine designs.

More detailed CAD-models and quality requirements will be sent to the CfP applicant after an NDA with Topic Manager has been signed, see remarks section at the end of this topic description.

Task 4: Weldability of cast alloys

Casting parameters and the post casting thermal treatment will be varied in order to explore the influence of casting parameter on weldability. Welding trials will be performed to assess weldability.

Task 5: Casting of component-like geometries

As the final activity of this project a final component geometry (similar to fig 1) will be cast with the high temperature alloy in approximately ten units to verify that the process parameters developed in task 1 to 4 are meeting the requirements and robustness targets. The castings will undergo dimensional control, x-ray inspection and will be cut up for microscopic inspection.

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

- The CfP partner needs to master vacuum investment casting of complex geometry Ni-base alloys.
- The CfP partner needs testing and analysis equipment for evaluating the casting trials, or an available supply network. This includes e.g. dimensional control, fluorescent penetrant inspection X-ray, metallography and mechanical testing according to aerospace standards.
- It is considered beneficial if the CfP partner has extensive experience in numerical simulation of the casting process.
- Experience in performing applied collaborative industrial research in international environment is considered as essential.
- Experience in of castability trials and the typical toolings used to create the specific casting samples for castability trials.
- The applicant is preferentially an institute/university, if possible in cooperation with a foundry, especially for the component-like castings in Task 5.

3. Major deliverables and schedule 24 Months

Deliverable	Title	Description (if applicable)	Due date
D1	Detailed Project Plan	Task 1: schedule with milestones,	T0 + 1M
D2	Test plan for Design of Experiments for castability, reduced minimum wall thickness, and improved weldability	Task 2-5	T0 + 3M
D3	Documentation of casting trials including comparison to manufacturing process simulation	Task 2-5	T0 + 15M
D4	Documentation of first batch of casting trials	Task 2-4	T0 + 12M
D5	Documentation of final casting trial for one Ni alloy with limited castability	Task 5	T0+ 24M

4. Topic value (€)

The total value of this work package shall not exceed:

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 1.5 stage proposal process is considered. Organisations interested in this call are encouraged to contact Topic Manager to sign a non-disclosure agreement after which specific component geometries and material specifications are to be released. This will help the applicant to make a more specific proposal.

Raw material procurement is expected to be included in the scope of this study.

All documents need to be written in English.

Topic Description

CfP topic number	Title		
JTI-CS-2011-1-SAGE-05-013	Feasibility study and prototypes manufacturing of oil tank in thermoplastic for Helicopter Engine	Start date	*10/2011*
		End date	*04/2012*

1. Topic Description

The SAGE5 project aims at developing a new helicopter engine presenting significant improvements in term of noise and gaseous emissions

The project is dedicated to the development of an innovative oil tank

Reducing specific fuel consumption is a real challenge for future helicopter engines. This can be achieved by means of increasing the engine performance or reducing the weight. In this latter approach, replacing present metallic alloys by organic materials is an interesting way.

Today, the oil necessary to gears and bearings running is contained in gearbox casings. The aim of this project is to study and manufacture a specific integrated oil tank made in thermoplastic material :

- Oil tank integrating equipments mountings (oil filling plug, draining plug and oil level sight indicator)
- Pipes (oil flow circulation) to connect the gearbox casing and the oil pump to the tank

Description of oil tank :

- Thermoplastic material
- General dimensions : 400mmx450mmx150mm
- Differential pressure between internal and external: 15 kPa.
- Oil temperature range: -50°C;+120°C with a normal working temperature of 80°C.
- Compliant with HTS (High thermal stability) oils, fuel, cleaning agents

Description of pipes :

- Thermoplastic material (can be different from oil tank material)
- General dimensions : ∅ = 10-15 mm; L = 400-500 mm
- Pressure range : 150 kPa to 700 kPa depending pipe function
- Oil temperature range: -50°C;+120°C with a normal working temperature of 80°C.
- Compliant with HTS (High thermal stability) oils, fuel, cleaning agents

The attachment of the oil tank to the gearbox casing and of the pipes to the oil tank must be studied during the project. Necessity of junction inserts integration.

Based on functional requirements specified by Topic Manager, the partners will have to :

- Assess the feasibility of such a part
- Design the tank and the pipes
- Manufacture the tank and the pipes (5 prototypes)

Characterisation and validation tests will be requested. All tests can be performed by external labs :

- Characterisation: mechanical and physical properties, fluid compatibility and design data.
- Definition and realisation of validation tests (pressure resistance, dimensional, mechanical….)

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

This task can require several partners, exhibiting high and proven experience in designing and manufacturing thermoplastic composite parts, with international quality standards, and ready to share their experience in supporting the manufacturing aspects of the program.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date (months)
D1	- Assessment of the feasibility - Materials and processes propositions for choice - Risk analysis	Complete Report To be validated by the Topic manager	T0+6
D2	Materials and processes evaluation : - Material characterisation - Design data	Complete Report : Material characterisation and Design data To be validated by the Topic manager	T0+10
D3	Design (drawing and sizing) of the tank and the pipes	Included : part integration CAD files : CATIA V5 (catpart, catproduct)	T0+10
D4	Prototype manufacturing of 5 tanks and pipes	Process key parameters, NDT controls proposal and evaluation.	T0+14 (to be discussed)
D5	Validation tests and Controls	Synthesis report	T0+18

4. Topic value (€)

The total value of this work package shall not exceed:

450,000 €

[four hundred and fifty thousand euro]

This topic value is a maximum gross value for the work package.

Awards of up to 50-75% of this value may be made by the Clean Sky Joint Undertaking.

5. Remarks

If applicable

Topic Description

CfP topic number	Title		
JTI-CS-2011-1-SAGE-05-014	Hot environment unsteady pressure sensors	**Start date**	*10/2011*
		End date	*10/2013*

1. Topic Description

The SAGE5 project aims at developing a new helicopter engine that meets the ACARE targets in term of noise and greenhouse gas emissions reduction. Another constant concern of the engine manufacturer is to re-enforce flight safety issues.
In order to reach these two important goals, Topic Manager needs two kinds of adapted and reliable unsteady pressure sensors during the SAGE5 test campaign, one for acoustic risk reduction purpose, and the other one for engine monitoring purpose.
These sensors will share the same development scheme, and the same harsh environment, even if their purpose is very different.
For this reason, Topic Manager launches this project on two different unsteady pressure sensors.

In the following description, the word 'sensor' describes the sensing element and all its housing, including a pipe that will act as an interface with the engine, supports and electrical connectors.

It is expected that no sensor in the marketplace will meet these requirements. Therefore the sensors are expected with the following generic shape:

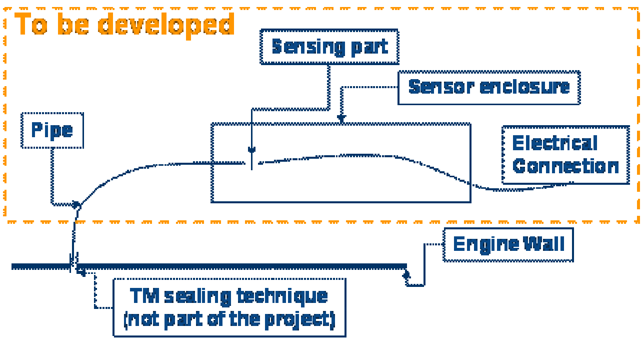
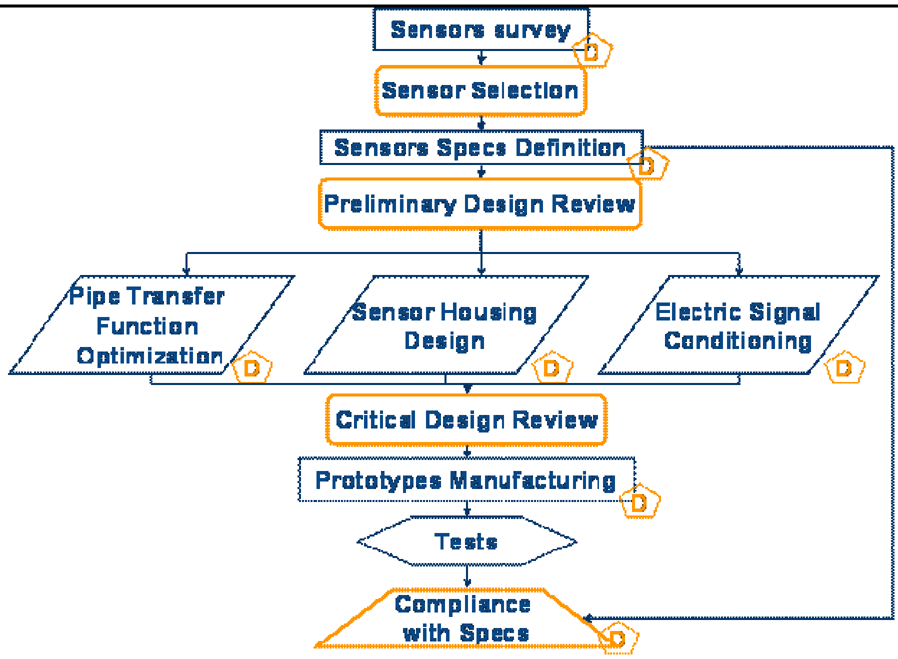


Figure 1: Sensor generic scheme

All the elements represented on the above scheme need to be developed and justified. Their purpose is described hereafter :

- Sensing part: the transducer itself, can be a ready made from existing marketplace, or modified, or brand new part
- Sensor enclosure: main purpose is to protect the sensing part and its connections and ensure the integrity of the whole assembly within the sensor constraints range
- Electrical connection: to transmit the signal to the exterior world
- Pipe: to sense and guide the unsteady pressure fluctuation within the engine towards the transducer

The development scheme for each sensor will be as in the following figure.



… where D is an expected deliverable.

The two sensors to be developed have quite different specifications:

Acoustic Specs :

Bandwidth(kHz) : 0~5	Bandwidth(kHz) : 15~30
Sensitivity Range : 110~170dB	Sensitivity Range : 130~180dB
Static pressure range : 15 bars	Static pressure range : 15 bars
Over Pressure : 2 times rated Pressure with no change in calibration	Over Pressure : 2 times rated Pressure with no change in calibration
Burst pressure : 3 times rated Pressure with no change in calibration	Burst pressure : 3 times rated Pressure with no change in calibration

Environmental Specs :

Pressure media	Gases
Operating temperature range	-55°C/350°C
Steady acceleration	10,000G
Linear vibration	Compatible with DO 160-E (vibration section)
Natural frequency	>40 KHz

Topic Manager will deliver complete specifications at the beginning of the project including: integration specs, environmental specs, acoustic specs, …

Tests will include temperature, pressure and vibration tests. Tests under realistic conditions would be appreciated.

5 sensors of each kind should be delivered, with attached characteristics.

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

The applicant shall exhibit high and proven experience in designing, manufacturing and studying unsteady sensors or related technologies.
Test facilities will be necessary to demonstrate sensors compliance to specifications.
Acoustic skills are required to optimize the pipe shape.
In case of response by a several partners, at least one of the partners (the coordinator) must exhibit experience in the management of a consortium.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date (months)
D1	Sensors Survey	List of marketplace potential candidates for both applications	T0+3
D2	Sensors Specs Definition	On the basis of former survey and preliminary sensor enclosure design rules, specs for the sensing element, the housing and wiring will be emitted	T0+9
D3	Pipe Transfert Function Optimisation Report	In order to guarantee the best signal shape /or ratio, an optimisation of the shape of the pipe will be done	T0+15
D4	Sensor Housing Design	Design of the housing, including full mechanical and thermal studies	T0+15
D5	Electric Signal Conditioning Report		T0+15
D6	Prototypes	5 sensors of each kind are expected	T0+17
D7	Sensors prototypes compliance with specs	Synthesis of the compliance tests, for each sensor	T0+24

4. Topic value (€)

The total value of this work package shall not exceed:

750,000 EUR

[seven hundred and fifty thousand euro]

This topic value is a maximum gross value for the work package.

Awards of up to 50-75% of this value may be made by the Clean Sky Joint Undertaking.

5. Remarks

Preliminary and Critical Design Review shall be included by the applicant in the process of this project in order to reduce the project risks.

The expected length of the proposals (part B) is 30 pages.

Topic Description

CfP topic number	Title		
JTI-CS-2011-1-SAGE-05-015	**Development of Quiet exhaust noise attenuation technologies**	Start date	10/2011
		End date	10/2013

1. Topic Description

The SAGE5 project aims at developing a new helicopter engine that meets the ACARE targets in term of noise and greenhouse gas emissions reduction. Concerning noise issues, it is of uttermost importance to reduce emitted noise at the closest to the noise source. Acoustic liners that prove to be efficient in flight need an important depth that cannot be integrated everywhere in the engine.

Past experiences gained during former EU-funded research projects on hot stream liners design show that promising attenuation could be achieved but integration issues of such liner very close to the source remains a challenge.

Two innovative noise reduction concepts are considered:
- Quiet plug
- Quiet Exhaust diffuser,

hopefully installed on the same piece of hardware

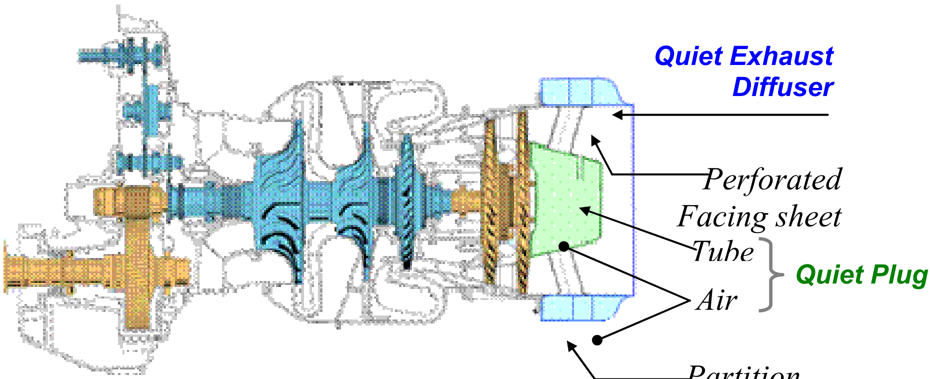


Figure 1. Engine with a quiet plug and a quiet exhaust diffuser (combined)

Mass and cost increase restrains the use of acoustic technologies on the current gas turbines. Therefore, the materials to be used for the manufacturing of the parts are:

- **Ferritic Stainless steel** as a low cost material. This material is currently not used in aeronautics. The project will determine if this transfer of technology from the automotive industry is feasible.
- **TiAl alloy** as a light alternative for only one exemplar of Quiet Exhaust diffuser. TiAl is a light material with outstanding thermal resistance capability. Moreover, the welding and forming of TiAl sheets is not trivial. Therefore, previous envisaged aeronautical applications have failed. Given the low stress level of the Quiet Plug and Exhaust Diffuser, this application is ideal to demonstrate all the mass gain associated with TiAl alloys.
- As the manufacturing activity is challenging due to the use of non proven materials, a **Nickel Based solution** could be envisaged as a back-up if the Ferritic and/or TiAl manufacturing process fails.

Academic study
Some partitions are required inside the liner (considered as a hollow cavity above a perforate plate) in order to maximise the acoustic attenuation. However, these partitions add costs and weight. The project shall provide experimental evidence of the trade-off between the number of partitions and the acoustic absorption, in order to deduce trade-offs between cost, mass and noise benefits.

In order to understand the link between the number (and orientation) of partitions and the acoustic efficiency, an experiment using a test bench with controlled flow/acoustic sources is expected, under cold conditions. This test bench must be provided by the selected partner.

This experiment will allow measuring the noise attenuation variation for each selected configuration of partitions and should discriminate the propagating waves in both directions in the duct, in order to provide a complete sound energy assessment, including higher modes.

The main influence of the following parameters on the noise attenuation variation is expected:

- The orientation of the partitions: azimuthally and axial
- The main flow Mach number (Mach = 0 and Mach < 0.3)
- The use of facing sheets optimised for
    - locally reacting case
    - non locally reacting case

Sufficient Sound Power must be provided through adequate sound sources, so that generated broadband noise signal remains visible after attenuation by the liner, well above main flow background noise.

12 test configurations are expected.

The output of this study, that is the optimal hardware configuration, will be transposed to design and manufacture the full-scale test hardware.
A numerical study used to correlate the experimental data will be done beside the project by Topic Manager.

Expected full-scale Hardware :

The figure below describes schematically the hardware to be manufactured with the integrated noise reduction technologies.

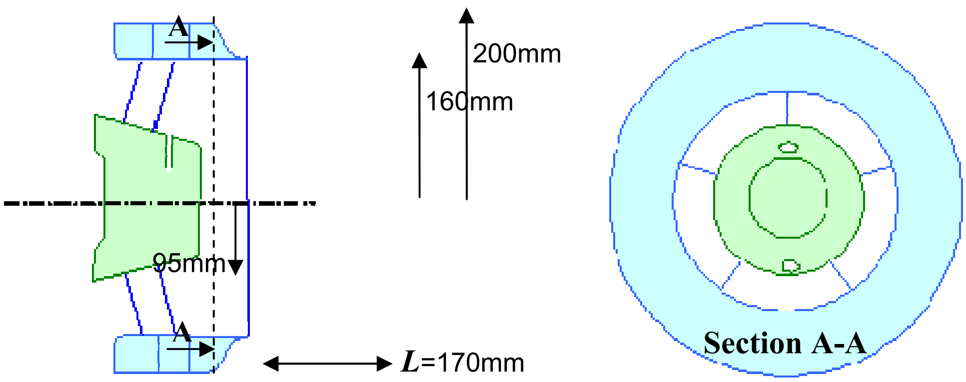


Figure 2. Scheme of the hardware to be manufactured

Three pieces of this kind are expected from the project:
- 1 One item manufactured with Ferritic alloy material (named : Short Quiet Exhaust) including:
    - A quiet plug tuned at one frequency.
    - An optimal acoustic liner on the exhaust diffuser (with optimal number of partitions) side with reduced treatment length (L).
- 2 One item manufactured with Ferritic alloy material (named : Quiet Exhaust) including :
    - A quiet plug tuned at one frequency.
    - An acoustic liner on the exhaust diffuser with the optimal number of partitions issued from the academic test campaign.
- 3 One item manufactured in TiAl (named : Long Quiet Exhaust)
    - A quiet plug tuned at two different frequencies.
    - An optimal acoustic liner on the exhaust diffuser side with additional length L compared to item 1.

The manufacturing of three items with different length will allow establishing a trade-off between cost and weight issues.

The consortium of partners will have to achieve the following task:
-1 Manufacturing the lab test bench, realisation of the academic test campaign and manufacturing of the test samples in order to determine the noise reduction variation with the number of azimuthal and axial partitions => recommendation about partitions distance and orientation
-2 Characterisation of the manufacturing capability of the new materials (Ferritic Alloys and TiAl) and improvement of the state art if necessary.
-3 Design three hardware items based on the acoustic specification provided by Topic Manager. The acoustic specifications will be the cavity depth of the acoustic treatment (Quiet Exhaust diffuser), perforation rate and size of the perforation for the facing sheet.
The aero lines of the parts will also be provided by Topic Manager.
The number of partitions will come from the academic study.
Consortium should prove that all three designs meet Mechanical & Thermal, Vibration and Technological Requirements.
- 4 Manufacture the three items

- 2 Items shall be manufactured in Ferritic Alloy
- 1 Item will be manufactured in TiAl. Depending of the maturity of the manufacturing process, a back-up solution in nickel based alloy or in Ferritic material will be manufactured aside.

The hardware will be tested on a turboshaft engine by Topic Manager in the framework of Clean Sky program, which will provide the final noise assessment of these technologies.

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

The applicant shall exhibit high and proven experience in designing, manufacturing and studying TiAl and Ferritic alloys or related technologies. Justification about previous realisations is required.

A test facility with flow is required with a flow path around 250mm diameter and flow Mach number M<0.3. The partner involved in the academic test should prove experience in the determination of the liner impedance (determined for each acoustic mode).

In case of response by a several partners, at least one of the partners (the coordinator) must exhibit experience in the management of a consortium.

3. Major deliverables and schedule

Deliverable	Title	Description (if applicable)	Due date
D1	Samples dedicated to the academic test	Hardware	T0+9
D2	Materials Characterisation (Ferritic and TiAl alloy)	This report will include results from additional material tests required (mainly high cycle fatigue and thermomecanical behaviour at high temperature with metallographic analysis taking into account thickness influence) prior the launch of the manufacturing phase.	T0+9
D3	Minutes of the Preliminary Design Review	The goal of the PDR is to check the ability to manufacture the hardware with Ferritic and TiAl alloys. If a NoGo is given for one of the materials, a back-up material (Nickel Based alloy) will be used to launch the detailed design study. Before moving to Nickel Based alloy solution, the evidences and justifications must be provided by the consortium that TiAl alloys solution can not be developed for this project.	T0+9
D4	Partition Test Report and test analysis	Report detailing the test realised, the global attenuation (and the modal transfer matrix) for each configuration (partition & Mach number) and a recommendation on the optimal number of partition.	T0+15

D5	Design Report	Report including drawings ,the technological study and justifying vibration and mechanical compliance to the specifications	T0+17
D6	Minutes of the Critical Design Review	The goal of the CDR is to launch the manufacturing phase and check that all inputs from the design phase are compliant with the specifications	T0+17
D7	Report on the manufacture of the 3 hardware	Hardware + Manufacturing process description	T0+24

4. Topic value (€)

The total value of this work package shall not exceed:

1,100,000 EUR

[one million one hundred thousand euro]

This topic value is a maximum gross value for the work package.

Awards of up to 50-75% of this value may be made by the Clean Sky Joint Undertaking.

5. Remarks

Preliminary and Critical Design Review shall be included by the applicant in the process of this project in order to reduce the project risks.

The expected length of the proposals (part B) is 30 pages.

====== End of Topic Descriptions for SAGE ======

Due to the large number of topics in this call and the inclusion of graphics in many topic descriptions, the topic descriptions for **SAGE, SFWA** and **SGO** have been moved into annexes of the Call Fiche. These annexes can be found in the additional documents section of the call web page. The main part of the Call Fiche contains the topic descriptions for **ECO, GRA** and **GRC.**