



Clean Sky 2 Joint Undertaking

Call Text

2nd Call for Proposals (CFP02): List and full description of Topics

- July 2015 -

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List of Topics for Calls for Partners (CFP02)

Identification Code	Title	Type of Action	Value (Funding in M€)
JTI-CS2-2015-CFP02-LPA-01-04	Active technologies for acoustic and vibration comfort	IA	0,75
JTI-CS2-2015-CFP02-LPA-01-05	Validation of aero-vibro-acoustic model on new aerodynamic configurations.	RIA	0,9
JTI-CS2-2015-CFP02-LPA-01-06	Laminar Horizontal Tail Plane full scale ground demonstrator	IA	1,5
JTI-CS2-2015-CFP02-LPA-01-07	Design, test and manufacturing of robust fluidic actuators	RIA	0,35
JTI-CS2-2015-CFP02-LPA-01-08	Drive and control system for piezoelectric AFC actuators	IA	0,35
JTI-CS2-2015-CFP02-LPA-01-09	Test aircraft preparation and qualification for Scaled Flight Testing ("PREP")	IA	2
JTI-CS2-2015-CFP02-LPA-01-10	Hybrid Prop. Demonstrator Components – Electric Power Drives ("DRIVE")	IA	1,5
JTI-CS2-2015-CFP02-LPA-01-11	Hybrid Propulsion Component Studies – Electrics	RIA	1,5
JTI-CS2-2015-CFP02-LPA-02-07	Landing gear large die-forged fitting with improved mechanical performance	IA	0,4
JTI-CS2-2015-CFP02-LPA-02-08	High production rate composite Keel Beam feasibility	IA	0,4
JTI-CS2-2015-CFP02-LPA-02-09	Integrated main landing gear bay	IA	0,6
JTI-CS2-2015-CFP02-LPA-02-10	Development of pultrusion manufacturing applications	IA	0,6
JTI-CS2-2015-CFP02-LPA-03-04	Touchscreen control panel for critical system management functions	IA	2
JTI-CS2-2015-CFP02-LPA-03-05	New flight crew oxygen mask concept for prolonged use in civil aircraft	IA	0,55
JTI-CS2-2015-CFP02-LPA-03-06	Head Up System integration in next generation cockpits	IA	1
JTI-CS2-2015-CFP02-LPA			14,4
JTI-CS2-2015-CFP02-REG-01-01	Smart-grid converter	RIA	0,8

Identification Code	Title	Type of Action	Value (Funding in M€)
JTI-CS2-2015-CFP02-REG-02-02	Powered WT model design and manufacturing of the FTB2 aircraft configuration for aerodynamic tests in wind tunnel at low and high Reynolds number	IA	2,5
JTI-CS2-2015-CFP02-REG			3,3
JTI-CS2-2015-CFP02-FRC-01-01	Development and demonstration of materials and manufacturing process for ultra-high reliability electric Anti-ice/De-ice thermal layers for high strain civil rotor blades and airframe sections of tiltrotor	IA	0,75
JTI-CS2-2015-CFP02-FRC-01-02	Development and demonstration of materials and manufacturing process for high power density homokinetic drive joints for civil rotor applications	IA	0,75
JTI-CS2-2015-CFP02-FRC-01-03	Development and validation of an optimised gearbox housing structural design and manufacturing process, based on additive layer manufacturing concept leading to a flight cleared demonstrator.	IA	1,75
JTI-CS2-2015-CFP02-FRC-01-04	Design, development and flight qualification of a highspeed/high torque novel freewheeling clutch architecture for tiltrotor main drive system	IA	0,75
JTI-CS2-2015-CFP02-FRC-01-05	Design, development and flight qualification of a novel, integrated high efficiency heat exchanger for tiltrotor transmission oil cooling	IA	0,35
JTI-CS2-2015-CFP02-FRC-01-06	Design, development, testing and qualification of a high-reliability integrated fuel gauging and distribution system providing active CG management in a civil tiltrotor	IA	0,75
JTI-CS2-2015-CFP02-FRC-02-09	Light weight, impact resistant, canopy for fast compound rotorcraft	IA	1
JTI-CS2-2015-CFP02-FRC-02-10	Multipurpose test rig for transmission gear boxes	IA	0,8
JTI-CS2-2015-CFP02-FRC-02-11	Design and realization of equipped engine compartments for a fast compound rotorcraft	AH	1,25
JTI-CS2-2015-CFP02-FRC-02-12	Fuel bladder tanks for a fast compound rotorcraft	IA	0,8
JTI-CS2-2015-CFP02-FRC-02-13	HVDC Generator	IA	1,2
JTI-CS2-2015-CFP02-FRC-02-14	Bird strike- and erosion resistant and fast maintainable windshields	IA	0,6
JTI-CS2-2015-CFP02-FRC			10,75
JTI-CS2-2015-CFP02-AIR-01-08	CROR Engine debris Middle level Impact and mechanical test	IA	0,4

Identification Code	Title	Type of Action	Value (Funding in M€)
JTI-CS2-2015-CFP02-AIR-01-09	Experimental characterization of turbulent pressure fluctuations on realistic Contra-Rotating Open Rotor (CROR) 2D airfoil in representative high subsonic Mach number.	IA	0,4
JTI-CS2-2015-CFP02-AIR-01-10	Erosion-resistant functional coatings	RIA	0,2
JTI-CS2-2015-CFP02-AIR-01-11	High accuracy and low intrusiveness in-flight wing shape and temperature measurements	RIA	0,55
JTI-CS2-2015-CFP02-AIR-01-12	Tool-Part-Interaction simulation process linked to laminate quality	RIA	0,35
JTI-CS2-2015-CFP02-AIR-01-13	Complex (composite) part Ultrasonic inspection facilitated by man-robot collaboration	RIA	0,35
JTI-CS2-2015-CFP02-AIR-01-14	Technology evaluation of immersive technologies for in-flight applications	IA	0,35
JTI-CS2-2015-CFP02-AIR-02-08	Ice protection system based on two-phase heat transport technologies integrated in representative engine intake structure	IA	0,5
JTI-CS2-2015-CFP02-AIR-02-09	HVDC Electrical Power Conversion and Distribution System Development	IA	1
JTI-CS2-2015-CFP02-AIR-02-10	Integrated airborne antenna for satellite communications in wing – fuselage airframe fairing	IA	1,1
JTI-CS2-2015-CFP02-AIR-02-11	Ice protection technology based on electromagnetic induction integrated in representative leading edge structure	RIA	0,25
JTI-CS2-2015-CFP02-AIR-02-12	System development for optical fiber sensing technology measurements for industrial aeronautical contexts: composite manufacturing plants, structural test platforms and airborne conditions	IA	0,35
JTI-CS2-2015-CFP02-AIR-02-13	Prototype Manufacturing Tooling for Single Parts Manufacturing of the Rotorless tail for LifeRCraft.	IA	0,75
JTI-CS2-2015-CFP02-AIR-02-14	Prototype Tooling for Sub-Assembly, Final Assembly and Transport of the Rotorless tail for the Compound RC.	IA	0,35
JTI-CS2-2015-CFP02-AIR-02-15	Design Against Distortion: Part distortion prediction, design for minimized distortion, carbon-epoxy aerospace parts	RIA	0,35
JTI-CS2-2015-CFP02-AIR-02-16	Process development for composite frames manufacturing with high production rate and low cost	IA	0,4
JTI-CS2-2015-CFP02-AIR			7,65

Identification Code	Title	Type of Action	Value (Funding in M€)
JTI-CS2-2015-CFP02-ENG-01-02	Conventional and Smart Bearings for Ground Test Demo	IA	2
JTI-CS2-2015-CFP02-ENG-01-03	More electric, advanced hydromechanics propeller control components	IA	0,25
JTI-CS2-2015-CFP02-ENG-01-04	Engine Mounting System (EMS) for Ground Test Turboprop Engine Demonstrator	IA	0,4
JTI-CS2-2015-CFP02-ENG-02-02	Integration of Laser Beam Melting Simulation in the tool landscape for process preparation of Additive Manufacturing (AM) for Aero Engine applications	RIA	0,7
JTI-CS2-2015-CFP02-ENG-02-03	Integration of a property simulation tool for integrated virtual design & manufacturing of forged discs/rotors for aero engine applications	RIA	0,45
JTI-CS2-2015-CFP02-ENG-03-01	Industry focused eco-design	RIA	2,5
JTI-CS2-2015-CFP02-ENG-03-02	Jet Noise Reduction Using Predictive Methods	RIA	0,4
JTI-CS2-2015-CFP02-ENG-03-03	Catalytic control of fuel properties for large VHBR engines	RIA	0,35
JTI-CS2-2015-CFP02-ENG-03-04	Development of coupled short intake / low speed fan methods and experimental validation	IA	2,8
JTI-CS2-2015-CFP01-ENG-04-05	Powerplant Shaft Dynamic and associated damping system	IA	0,35
JTI-CS2-2015-CFP02-ENG			10,2
JTI-CS2-2015-CFP02-SYS-01-01	Very high brightness & compact full color display for next generation eyes-out cockpit products	RIA	3,8
JTI-CS2-2015-CFP02-SYS-02-09	ALGeSMo (Advanced Landing Gear Sensing & Monitoring)	IA	2,4
JTI-CS2-2015-CFP02-SYS-02-10	Analysis of centrifugal compressor instabilities occurring with vaneless diffuser, at low mass flow momentum	IA	0,9
JTI-CS2-2015-CFP02-SYS-02-11	Innovative design of acoustic treatment for air conditioning system	IA	0,6
JTI-CS2-2015-CFP02-SYS-02-12	Eco Design : Optimization of SAA chromium free sealing process	IA	0,25
JTI-CS2-2015-CFP02-SYS-02-13	Analysis, validation and data collection of design and operating parameters for advanced cabin ventilation concepts related to future aircraft energy management systems	IA	2
JTI-CS2-2015-CFP02-SYS-03-01	Electromechanical actuator for primary moveable surfaces of small aircraft with health monitoring	IA	1
JTI-CS2-2015-CFP02-SYS-03-02	Passive thermo-acoustic insulation for small aircraft.	IA	0,4

Identification Code	Title	Type of Action	Value (Funding in M€)
JTI-CS2-2015-CFP02-SYS-03-03	Database of dynamic material properties for selected materials commonly used in aircraft industry.	IA	0,3
JTI-CS2-2015-CFP02-SYS			11,65
TOTAL			57,95

1.1. Clean Sky 2 – Large Passenger Aircraft IAPD

I. Active technologies for acoustic and vibration comfort

Type of action (RIA or IA)	IA		
Programme Area	LPA Platform 1		
Joint Technical Programme (JTP) Ref.	WP1.5		
Indicative Funding Topic Value (in k€)	750 k€		
Duration of the action (in Months)	36 months	Indicative Start Date ¹	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-LPA-01-04	Active technologies for acoustic and vibration comfort
Short description (3 lines)	
To progress on airframe and engine efficiency while supporting the high level of the customer comfort requested, new technologies of noise and vibration reduction have to be developed to face the new evolutions of business jet design. It is proposed to develop and evaluate active technologies for 2 different problems: active control systems for reducing cabin noise from engine vibration, and active control systems for reducing global fuselage vibration from aerodynamic excitations.	

¹ The start date corresponds to actual start date with all legal documents in place.

1. Background

Within WP 1.1 of LPA, the control of cabin and cockpit noise will be addressed with the overall objective of progressing on Airframe efficiency. The proposed topic will contribute to achieve a high level of passenger's environment quality and passenger and pilot comfort while limiting the weight penalty and thus the environmental cost of a quiet or vibration less cabin interior.

The new design evolutions towards bigger engines, towards lighter/more flexible aircraft structure and towards longer and bigger aircraft fuselage may provide more vibrations as well in the frequency audible range with a potential cabin noise increase from engine vibrations as in the low frequency range from aerodynamic excitations which has a strong impact on vibration comfort.

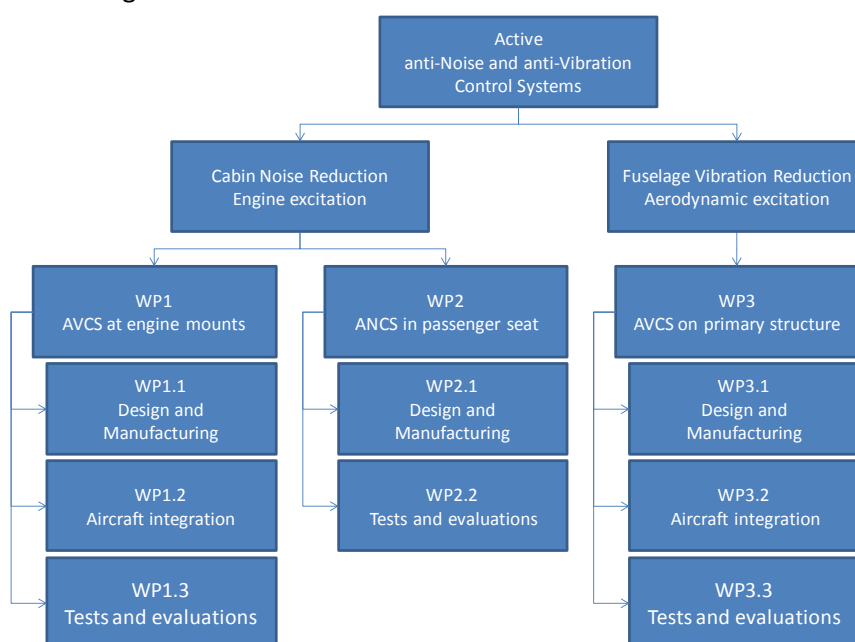
To tackle these 2 problems - acoustic comfort from engine vibrations and vibration comfort from aerodynamic excitation - it is proposed to develop and evaluate active technologies as an improvement to passive technologies which have their own limits (mass and performance).

Similar active technologies exist and are mature for other applications such as vibration cancellation in cars or in industrial machinery; first experiences have shown that they are not directly applicable to aeronautics but they are certainly a good starting point to develop the system described in the present topic.

Three different technologies related each one to a WP will be assessed:

- WP1 : For acoustic comfort from engine vibrations, Active anti-Vibration Control Systems (AVCS) at engine mounts will be developed/evaluated
- WP2 : For acoustic comfort from engine vibrations, Active anti-Noise Control Systems (ANCS) in passenger seats will be developed/evaluated
- WP3 : For vibration comfort from aerodynamic excitations, Active anti-Vibration Control Systems (AVCS) at optimized fuselage position will be developed/evaluated

Technical and economic feasibility and performance will be assessed thanks to full scale demonstrators and in-flight tests.



Topic Work Breakdown Structure of Active Control Demonstration

WP1 - AVCS for engine vibration reduction

The WP1 is dedicated to demonstrate the effectiveness of an Active anti-Vibration Control System (AVCS) at engine mounts. The technology is based on several actuators which delivers an effort near engine mounts to counter small vibrations measured by vibration sensors with a specific control law. The control should provide a engine noise reduction of more or less 15 dB at the typically N1, N2 engine rotational frequencies around 110Hz and 400Hz. The complete system mass by engine should not exceed 15 kg.

WP2 - ANCS for engine vibration reduction

The aim of the WP2 is to demonstrate the effectiveness of an Active anti-Noise Control System (ANCS) for aircraft passenger seat. The system integrated inside each passenger seat consists of loudspeakers, microphones and control law device. The control should target a engine noise reduction of 15 dB and provide at least 10 dB at the typically N1, N2 engine rotational frequencies around 110Hz and 400Hz. For the purpose of the flight test demonstration, the complete system should deal with the two "three seats" sofa face-to-face belonging to the test aircraft and its mass should not exceed 9 kg.

WP3 - AVCS for aerodynamic vibration reduction

The objective of the technology developped in this WP3 is to significantly improve the level of comfort of business jet. The Active anti-Vibration Control System (AVCS) is based on one or several actuators which delivers an effort on the structure to counter small vibrations measured by sensors. In order to deliver the optimal effort, the actuator is controlled by a specific control law feeded with these sensors. The system that will be developped should provide a reduction of 6 dB RMS , in the frequency band 5Hz-15Hz, of the fuselage floor acceleration with respect to typical in-flight aerodynamic perturbations. The complete system mass should not exceed 30kg.

2. Scope of work

Tasks			
Ref. No.	Title - Description		Due Date
AVCS for engine vibration reduction	T1.1	Conceptual design, specifications and installation constraints	T0+6
	T1.2	Design (actuator, sensors, amplifier, controller)	T0+12
	T1.3	Manufacturing and assembling	T0+18
	T1.4	Aircraft integration	T0+24
	T1.5	Demonstration Tests (ground, in-flight)	T0+30
	T1.6	Results assessment	T0+36
ANCS for engine noise reduction	T2.1	Conceptual design and specifications	T0+6
	T2.2	Design (actuator, sensors, amplifier, controller)	T0+12
	T2.3	Manufacturing and assembling	T0+18
	T2.4	Aircraft integration	T0+24
	T2.5	Demonstration Tests (ground, in-flight)	T0+30
	T2.6	Results assessment	T0+36
AVCS for aerodynamic vibration reduction	T3.1	Conceptual design, specifications and installation constraints	T0+6
	T3.2	Design (actuator, sensors, amplifier, controller)	T0+12
	T3.3	Manufacturing and assembling	T0+18
	T3.4	Aircraft integration	T0+24
	T3.5	Demonstration Tests (ground, in-flight)	T0+30
	T3.6	Results assessment	T0+36
T4.0	Project final assessment		T0+36

For each system, activities are separated into six tasks:

- the first tasks TX.1 consists in verifying the feasibility according to the system requirements in terms of frequencies, amplitudes, efficiency and installation constraints provided by the airframe manufacturer,
- the second tasks TX.2 performed by the system supplier is dedicated to the design of the system,
- the third tasks TX.3 performed by the system supplier is dedicated to the manufacturing and the assembling of the system,
- the fourth tasks TX.4 consists in contributing to the integration of the system (installation design, efficiency simulation, actual integration) within test aircraft, the system supplier will have to acquire for modification some existing interface parts such as seats or support belonging to the test aircraft and will assist the airframer for the installation,
- the fifth tasks TX.5 surrounds all the test activities (test plan, permit to fly, test report...), the applicant should plan to prepare and carry out ground and flight test for one or two weeks

but aircraft operations and operational costs will be handled by the topic manager – the applicant will be expected to participate to the tests at the airframer facility for two or three weeks (depending on the WP) providing support for operating the system and acquiring system data but the test aircraft manufacturer will lead these activities according to its own procedures,

- and the last tasks TX.6 is dedicated to the results assessments that will be gathered together (T4.0) to conclude the project final assessment.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables				
Ref. No.	Title - Description		Type	Due Date
AVCS for engine vibration reduction	Preliminary Design Review documents			
	D1.1	Preliminary estimation and specifications Technical proposal	Report	T0+6
	Critical Design Review documents			
	D1.2	System design Efficiency estimations and installation design	Simulation Report / CAE- CAD models	T0+12
	System delivery			
	D1.3	Control system (actuator, sensors, amplifier, controller, software) Quality report (hardware and functional tests)	System / Report	T0+18
	Ground Test			
	D1.4	Ground test Readiness Review documents	Report	T0+24
	D1.5	Ground Test Report	Report	T0+30
	In-Flight Test			
	D1.6	In-Flight test Readiness Review documents A/C integration justification and permit to fly	Report	T0+30
	D1.7	In-Flight Test Report	Report	T0+36
ANCS for engine vibration reduction	Preliminary Design Review documents			
	D2.1	Preliminary estimation and specifications Technical proposal	Report	T0+6
	Critical Design Review documents			
	D2.2	Efficiency estimations and installation design System design	Report / CAE- CAD models	T0+12
	System delivery			
	D2.3	Seat equipped with ANCS Quality report (hardware and functional tests)	System / Report	T0+18
	Ground and in-flight Tests			
	D2.4	Test plan	Report	T0+24
	D2.5	Test Report	Report	T0+30
AVCS for aerodynamic vibration reduction	Preliminary Design Review documents			
	D3.1	Preliminary estimation and specifications Technical proposal	Report	T0+6
	Critical Design Review documents			
	D3.2	System design Efficiency estimations and installation design	Report / CAE- CAD models	T0+12

Deliverables				
	System delivery			
	D3.3	Control system (actuator, sensors, amplifier, controller, software) Quality report (hardware and functional tests)	System / Report	T0+18
	Ground Test			
	D3.4	Ground test Readiness Review documents	Report	T0+24
	D3.5	Ground Test Report	Report	T0+30
	In-Flight Test			
	D3.6	In-Flight test Readiness Review documents A/C integration justification and permit to fly	Report	T0+30
	D3.7	In-Flight Test Report	Report	T0+36
D4.0	Project final assessment document		Report	T0+36

Milestones (when appropriate)				
Ref. No.	Title - Description		Type	Due Date
AVCS for engine vibration reduction	M1.1	Preliminary Design Review		T0+6
	M1.2	Critical Design Review		T0+12
	M1.3	System Delivery		T0+18
	M1.4	Ground Test Readiness Review		T0+24
	M1.5	Ground Test Campaign End		T0+27
	M1.6	in-Flight Test Readiness Review (Permit to fly)		T0+27
	M1.7	Flight Test Campaign End		T0+30
ANCS for engine vibration reduction	M2.1	Preliminary Design Review		T0+6
	M2.2	Critical Design Review		T0+12
	M2.3	System Delivery		T0+18
	M2.4	Test Campaign End		T0+30
AVCS for aerodynamic vibration reduction	M3.1	Preliminary Design Review		T0+6
	M3.2	Critical Design Review		T0+12
	M3.3	System Delivery		T0+18
	M3.4	Ground Test Readiness Review		T0+24
	M3.5	Ground Test Campaign End		T0+27
	M3.6	in-Flight Test Readiness Review (Permit to flight)		T0+27
	M3.7	Flight Test Campaign End		T0+30
M4.0	Dissemination			T0+36

4. Special skills, Capabilities, Certification expected from the Applicant(s)

- For WP1 and WP2, experience in design and manufacturing of Active anti-Vibration Control Systems in the aeronautical industry :
 - Tools for vibration analysis,
 - experience in technological research and development in active control,
 - development of methodology and system for the vibration control,
 - in-flight qualification tests and/or “Flight Clearance”
- For WP3, experience in design and manufacturing of Active anti-Noise Control Systems in aeronautical seat :
 - Tools for noise analysis,
 - experience in technological research and development in active control,
 - development of methodology and system for the noise control,
 - in-flight qualification tests and/or “Flight Clearance”

II. Validation of aero-vibro-acoustic model on new aerodynamic configurations.

Type of action (RIA or IA)	RIA		
Programme Area	LPA Platform 1		
Joint Technical Programme (JTP) Ref.	WP1.5		
Indicative Funding Topic Value (in k€)	900 k€		
Duration of the action (in Months)	36 months	Indicative Start Date²	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-LPA-01-05	Validation of aero-vibro-acoustic model on new aerodynamic configurations.
Short description (3 lines)	
Due to new fuselage shape and different cruise mach numbers, this project aims at improving knowledge on turbulent boundary layer noise and its propagation into the fuselage structure. The influence of pressure gradients and fuselage shapes will be investigated through both experimental measurements and numerical simulations. Wind tunnel test on a modular mock-up will provide data about aero-acoustics and structural dynamics under non homogeneous loading.	

² The start date corresponds to actual start date with all legal documents in place.

1. Background

In modern turbofan aircraft one of the major sources of interior noise affecting the passenger comfort is the turbulent boundary layer. This is due to the successful reduction of engine noise. With futur turbofan aircraft, due to new aerodynamics configuration and engine characteristics, the balance between noise coming from turbulent boundary layer (TBL) and engine noise will be modify.

Therefore, to avoid a waste of mass wich is related to a waste of green efficiency, the understanding of the TBL excitation is the key to an efficient control of interior noise and vibration for a passenger friendly cokpit and cabin. In contrast to this fact neither the physics of the TBL nor the simulation of the vibroacoustic response are thoroughly understood. Previous R&T projects permitted to determine the pressure fluctuations via tests and to simulate the vibroacoustic response of simple and small size structures.

Interest in cockpit noise mitigation has recently received a renewed attention. This is also driven by safety aspects due to higher awareness of pilots in low noise environments. It has been demonstrated by a US aircraft manufacturer that it is possible to alleviate interior noise through the appropriate design of the forward fuselage. A 2-3 dB improvements in flight deck noise can be expected. The challenge lies in the understanding of the relation between overall aerodynamic (TBL noise) pressure fluctuation level and the interior noise, the relation being highly non-linear. A half decibel of TBL noise increase, or a 6% average flow speed increase, could results in a 1.5 dB interior noise increase.

It is therefore the main objective of this project to investigate both the turbulent processes of the fluid physics in relation to aerodynamic-excited noise generation in the TBL and the structural response of realistic structures exposed to this turbulent aerodynamic excitation. In general, there are two possibilities to further reduce interior noise. The first is to provide means for reducing the excitation itself by modifying the TBL through an optimised aerody-namic design and/or with palliatives devices and the second is to design the structure in such a way that it is poorly excited by the TBL. Both require a good understanding and modelling of the pressure fluctuations and noise generated by a turbulent boundary layer on complex shapes, and the structural response to such fluctuations, which the project should provide, starting from state of the art models and using both numerical and experimental approaches to progress further.

2. Scope of work

The following tasks are to be performed by the Partner:

Tasks		
Ref. No.	Title - Description	Due Date
T0	State of the art of existing turbulent boundary layer noise models	Jun 2016
T1	State of the art and innovation on measurement tools	Fev 2017
T2	Design, manufacturing and instrumentation of the model	Jun 2017
T3	Wind tunnel testing in an anechoic wind tunnel test section	Sep 2017
T4	aero-vibro-acoustic simulation of the model	Dec 2017
T5	Test results analysis and comparison to aero-vibro-acoustic simulation	Apr 2018
T6	Synthesis	Sep 2018

Task 0 : State of the art of existing turbulent boundary layer noise models

The applicant should make a study of the existing model of the boundary layer noise in order to have a good overview of the theory.

Task 1: State of the art and innovation on measurement tools

The applicant will propose innovative tools of measurements for the noise fluctuation inside the boundary layer.

The model should be modular in terms of configuration but also in terms of measurements. Furthermore, a part of fuselage from our testing laboratory should be included to the mock up.

For both those reasons, the measurements tools should also be modular, easily interchangeable, easily moved.

The capacity of the microphones depends on the size of the model, but it should measure up to 5000Hz full size.

Task 2: Design, manufacturing and instrumentation of the model

Design of the model:

The applicant will design the detailed model for the mock up. The baseline of the model will be defined by Dassault Aviation:

The mock up should include a full scale airframe representative fuselage part with a panel along an inner anechoic acoustic cavity. This will be the direct limitation for the size of the model which thus should be around 6 m long and 2.5 m large (height would be defined according to wind tunnel constraints). This part should be totally modally separated from the rest of the structure. The

dynamic behaviour of the mock-up should be perfectly controlled up to 5000 Hz.

The mock up should be modular in order to allow: modification of the external cockpit definition to modify the repartition of the pressure gradient and installation of antennas on the fuselage.

A fake pressure transducers instrumented window will be added to the model. Specific care should be dedicated to any unwanted noise sources, for instance, there should be a smooth ending at the rear of the model to avoid any noise sources generation.

Manufacturing of the model:

The applicant should manufacture the model as designed. It is important for the model to have no gap or step to avoid any flow perturbation.

Instrumentation of the model:

The model should be instrumented with pressure transducers defined in task 1 to measure the wall pressure fluctuations. This instrumentation should have no impact on the flow propagation on the surface and no impact on the panel or any structural part included in the model. This means that they need to be perfectly flush mounted but also that it is not possible to screw them.

The fake window may also be instrumented by kulites.

Finally, to measure the vibration and determine the response of the structure, some specific areas of the model should be instrumented with accelerometers.

The pressure and the vibration measurements should be up to 6KHz at full scale. The sensitivity of the microphones should be around 1 PSI. Accelerometers of the class 1g would be needed.

Those new instrumentation tools should at the end be applicable for flight measurement testing. This induces specific environmental requirements for the microphones: for instance it should be compatible of temperatures ranging from minus 40 to 70 °C; it should also withstand high humidity levels .

In brief, measurements should include:

- steady pressures,
- A recording system with around 150 simultaneous unsteady channels (to be confirmed)
- At least 30 accelerometers to determine and correlate vibration in 6 different areas of the fuselage panel,
- a standard sound intensity probe behind the panel (with a microphone array)

Task 3: wind tunnel testing

The applicant will perform the wind tunnel testing of the model. The wind tunnel should be big enough for the model and it should be an acoustic wind tunnel with low background noise. Low subsonic tunnel speeds are targeted for this test.

To be able to correlate pressure with vibration measurements and acoustic response of the cavity, a preliminary vibration and acoustic test of the mock-up up to 5000 Hz will be performed. The dynamic analysis will include structural transfer functions from some point excitation location to accelerometers and inner microphones, modal and damping identification and energy transfer from acoustic excitation to vibration and acoustic response.

Task 4: aero-vibro-acoustic simulation of the model

The applicant should perform a simulation of the boundary layer developing on the model. This task is dedicated to the simulation of flow regions where the attached TBL becomes non-equilibrium and potentially generates intense vibro-acoustic noise. These regions can be found on a realistic fuselage configuration with either attached flow or with flow separation and vortex motions that may occur in the presence of an adverse pressure gradient due to, for example, surface curvature, protuberances and sinks. The simulations will serve to explore the nature of the pressure fluctuations in the wall layer around the fuselage, in particular the role of their convective and -especially for high subsonic speeds- their acoustic component. The main target is the analysis and the determination of the pressure fluctuations that are associated with the turbulent boundary layer excitation.

Dynamic and acoustic behaviour of the mock-up with its cavity will be reproduced thanks to computation with a relevant structural model and transfer function between the pressure field and the fuselage skin.

Task 5: Test results analysis and comparison to aero-vibro-acoustic simulation

The results from Task 4 will be compared to test results to obtain an aero_vibro_acoustic noise model of the test configuration

Task 6: Synthesis

The final synthesis report will be delivered at the end of this task.

All 6 tasks above are integral part of the topic and should be proposed by applicants.

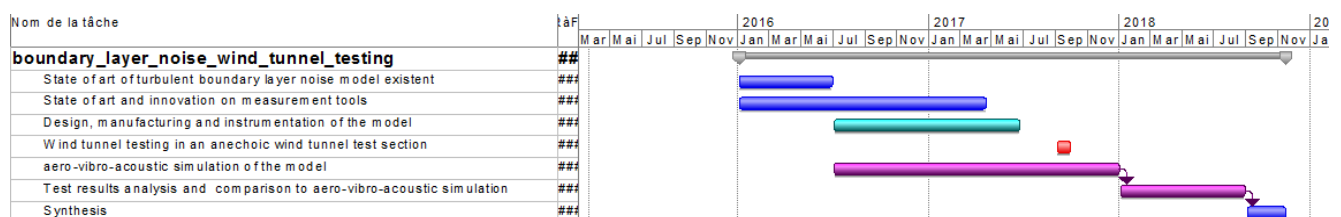
3. Major deliverables/ Milestones and schedule (estimate)

Major deliverables and milestones are summarized on the following tables:

Deliverables			
Ref. No.	Title - Description	Type	Due Date
D1	State of the art report on boundary layer noise modelling	report	Jul 2016
D2	Preliminary design of the model	Report	Sep2016
D3	Frozen design of the model (mock-up, sensors and stress report)	Report	Oct 2016
D4	Report on innovative measurement tools development	report	Fev 2017
D5	Model delivery and quality report	Model	Jun 2017
D6	Wind tunnel test specifications and vibration test specifications	report	Jun 2017
D7	Wind tunnel test report and vibration test report	report	Dec 2017
D8	Data delivery of the wind tunnel test results	Data	Jan 2018
D9	Turbulent boundary layer noise sources simulation and description of models	report	Jun 2018
D10	Final report on data analysis	report	Dec 2018

Milestones		
Ref. No.	Title - Description	Due Date
M1	Preliminary Model design review	Sep2016
M2	Critical Model design review	Oct 2016
M3	Development of new measurement tools	Apr 2017
M4	Model delivery and model review	Jun 2017
M5	Model simulation status	Aug 2017
M5	Vibration testing	Jul 2017
M6	Wind tunnel testing	Sep2017
M7	Wind tunnel test data delivery	Jan 2018
M8	Final simulation	Jun 2018

The overall proposed schedule is represented on the following figure:



4. Special skills, Capabilities, Certification expected from the Applicant(s)

The applicant should have experience on development of innovative acoustic measurement tools and capability to improve the TRL of the concepts up to 4-5.

The applicant should have a wind tunnel test section compatible with the size of the model. The wind tunnel should be designed for acoustic testing with very low background noise levels

The applicant should have experience on design and manufacturing of the mock up.

The applicant should have experience on turbulent boundary layer noise and structure response modelling.

The applicant should have experience on aero-vibro-acoustic measurements and analysis up to 5 kHz.

III. Laminar Horizontal Tail Plane full scale ground demonstrator

Type of action (RIA or IA)	IA		
Programme Area	LPA		
Joint Technical Programme (JTP) Ref.	WP 1.4 – Hybrid Laminar Flow Control Large Scale Demonstration		
Indicative Funding Topic Value (in k€)	1500 k€		
Duration of the action (in Months)	23 months	Indicative Start Date³	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-LPA-01-06	Laminar Horizontal Tail Plane full scale ground demonstrator
Short description (3 lines)	
The aim of this project is the demonstration of the feasibility and the aerodynamics of a natural laminar horizontal tail plane. The partner will have to participate to its design and manufacture. The overall model will be representative to the outer 2,5m span full scale HTP of a bizjet instrumented and compatible with wind-tunnel test.	

³ The start date corresponds to actual start date with all legal documents in place.

1. Background

The activity is a contribution to WP1.4.

The reduction of the aerodynamic drag of business aircraft by application of laminar technology is one of the very few remaining viable opportunities that can offer a potential of a double digit decrease of specific fuel burn. For business aircraft, the Natural Laminar Flow (NLF) technology is currently pushed forward to maturity in Clean Sky SFWA, the objective in Clean Sky 2 is to go further with large scale demonstrator in order to reach higher TRL.

Target benefit is to achieve a gain of at least 1% drag at aircraft level in cruise conditions compared to a classical HTP without penalty in the off-design conditions.

The key technical objective is fully multidisciplinary nature: combine a low weight structure that enables high surface quality and low tolerances in waviness, steps and gaps, while ensuring appropriate integration and access to all relevant systems. The design and the manufacturing are key elements of this project.

2. Scope of work

The objective of the work is to perform the design, manufacturing of a natural laminar HTP.

The WBS is as followed:

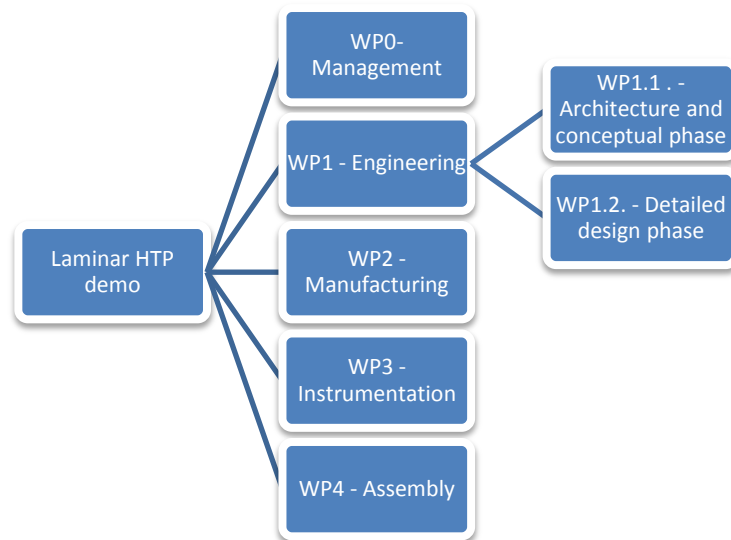


Figure 1: Work Breakdown Structure

In a second phase a wind tunnel test of the manufactured HTP is envisaged, under the Airframer's responsibility and outside of the scope of the present call. The applicant will be expected to transfer the manufactured HTP to the Airframer for testing, and to support the preparation of the test as described in paragraphs 2.4 and 2.5.

2.1. Management tasks – WP0

This work package will provide the management of the project in order to ensure that all the obligation of the Applicant are fully respected, from a contractual, financial and technical point of view.

The Applicant shall organise the work in all the others WP and report to Topic Manager (TM) all along the project.

2.2. Engineering tasks - WP1

2.2.1. Scope

The Applicant is expected to design entirely the natural laminar flow Horizontal Tail Plane demonstrator and its interface with the wind tunnel testing facility.

This engineering definition must be sufficient for parts manufacturing by the Applicant and for final assembly by the TM.

The proposed architecture for the demonstrator is as follows:

- Torsion box (TB): part of laminar zone
 - 2 CFRP panels (with preferably 1 panel with no through thickness fasteners)

- 2 aluminium spars
- 6 aluminium ribs
- 1 access panel (issued from the panel with through thickness fasteners)
- Fixed leading edge (FLE): part of laminar zone, double curvature shape
 - CFRP skin and ribs
 - Metallic anti-erosion nose reinforcement compliant with aesthetic and laminar flow requirements (e.g. 1 layer of Copper-Nickel electro-deposition)
- Trailing edge (TE)
 - Fixed trailing edge structure and hinges (aluminium)
 - 1 movable surface (technology TBD)
 - Actuation system: actuator, mechanism and crank shaft
- Tip fairing: part of laminar zone
 - CFRP skin and ribs
- Laminar zone separator “gaster bump” or Anti Contamination Device (ACD)
 - Fairing (technology TBD)
- Root-to-wind tunnel junction
 - Aluminium fittings
- Aero test features
 - 60 pressure ports along 2 wind-direction stations of the leading edge and torsion box
 - 6 interchangeable patches (1 in the FLE, 2 in the TB along 1 wind-direction station on the top and lower surface)

The design work is planned in two design phases: a conceptual and architecture phase, and then a detailed definition phase.

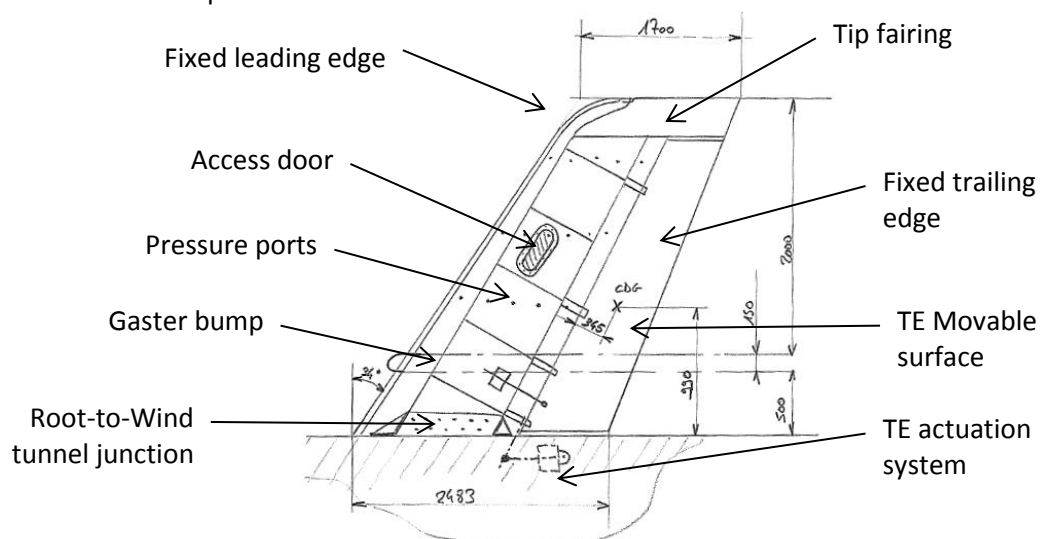


Figure 2: Horizontal Tail Plane demonstrator for aerodynamic test

2.2.2. Architectural and conceptual phase - WP1.1.

The aircraft manufacturer, represented by a Topic Manager (TM) will lead this joint design phase and the applicant is expected to manage the development of the followings topics:

- Architecture of its Airframe package, optimised for natural laminar flow.
- Design principles applied to its Airframe package:
 - Structural joints and interfaces
 - Laminar surface treatments for steps/gaps/fastener heads/etc
 - Mechanisms and actuation system
 - Test features (pressure probes, interchangeable patches, etc)
 - Assembly principles
- System installation layout design (positioning, routing and attachment).
- Choice of materials, manufacturing processes and protective treatments in accordance with the overall project requirements (representative of aircraft technologies).
- Initial substantiation of the Airframe package structure (pre-sizing) with loads provided by the TM.

During this phase the applicant is expected to propose innovative solutions that fit the objective of natural laminar flow requirements and performances.

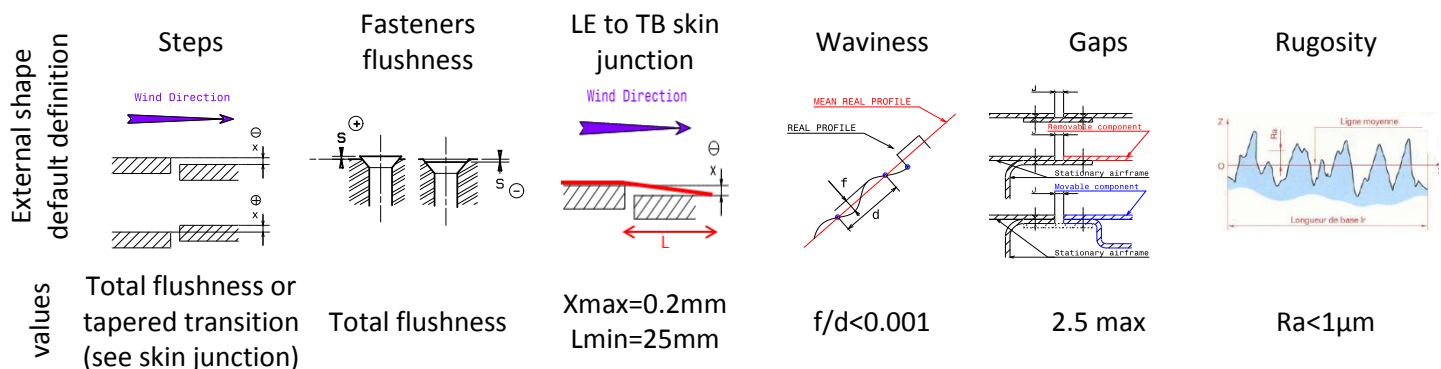


Figure 3: Quality requirements for laminarity

The TM and the applicant will iterate during the architecture and conceptual design phase to define all the necessary design principles that will be used to define the detailed design of the Airframe package. For efficiency it is advised to the applicant to locate its design team in the TM company design office in Saint-Cloud (FRANCE) during this phase to ensure easy design iterations. This phase and its deliverables will be validated with the TM through the Preliminary Design Review.

2.2.3. Detailed definition phase - WP1.2.

The Applicant will lead this design phase with the assistance of the TM team to validate the engineering definition of its Airframe package. Monthly Progress Meetings will be held during this phase in order to review and validate the Applicant design work. This phase and its deliverables will be validated by the TM through the Critical Design Review before parts manufacturing begin.

The Applicant shall perform all the engineering tasks under its responsibility and will support the TM engineering activities and any other suppliers (e.g. the Wind Tunnel facility) in interface with its Work package for all necessary engineering activities.

Globally, the Applicant shall define interface control documents, perform detailed design, substantiate and test the definition, perform production follow-up and validation activities.

The detailed engineering activities are as follows:

- The Applicant shall issue and update drawings and models, engineering data, and reports for its Work package as requested in the deliverable list detailed in §3.
- In conjunction with the TM, the Applicant shall participate in the elaboration of the overall project models and drawings.
- The Applicant shall perform the complete detailed design to enable parts manufacturing and assembly.
- The Applicant shall perform structural analyses, coupon, sub-component and component tests and participate as required in the overall project tests, to comply with safety, design and operating requirements.
- The Applicant is responsible for its Airframe package structural substantiation (analysis supported by tests) in static and fatigue. General external Airframe loads will be provided by the TM.
- The Applicant is responsible of the Airframe behaviour and of the modal analysis of all the surfaces and, if necessary, will trim movable surfaces modal characteristics to be free of flutter.

2.3. Manufacturing tasks – WP2

The objectives of WP2 is to provide a Horizontal Tail Plane Demonstrator for aeodynamic tests. The figure 1 shows a preliminary design of the demonstrator and the main dimensions. The HTP demonstrator will be fixed on the surface of the wind tunnel by an attachment included in the call. The HTP demonstrator includes static pressure ports which be implemented before the assembly.

After assembly, integration of laminar functions will be added by the TM team in relation with the applicant of the demonstrator.

The applicant will be responsible for:

- The supplying of raw material
- The manufacture of each part of the demonstrator (the choice of manufacturing processes will be decided jointly with the TM)
- The dimensional control of each part,
- The assembly of each sub-elements,
- The drilling of pressure holes,
- The assembly of static pressure ports equipped with pipes and connectors
- The jig assembly of HTP demonstrator
- The handling system of demonstrator (e.g. cradle, hoisting point, transportation box, etc...)

The applicant is responsible for the whole manufacturing of the single parts of the demonstrator. The design and the manufacturing requirements (materials, technical specifications,...) are an outcome of Engineering phase (WP1.). Any evolution of the HTP demonstrator package shall be managed through the TM team and must be formally accepted by the TM. The manufacturing of single parts and the assembly of HTP demonstrator will follow Manufacturing and Production requirements and

Quality requirements.

The table below describes the main parts and auxiliary part need for the HTP demonstrator:

Part	Material	Main dimension/surface (mm, m ²)	Short description of process and design (will be confirmed with the launching of project)
HTP BOX			
Torsion box: 1 top stiffened panel	Carbone/epoxy	2.20m ²	Autoclave – longitudinal stiffeners for design
Torsion box: 1 bottom stiffened panel	Carbone /epoxy	2.20m ²	Autoclave – longitudinal and transversal stiffeners for design (see figure 2)
Torsion box: 2 spars	Aluminum	2500mm	Integral machining
Torsion box: 6 ribs	Alumimum		Integral machining
Torsion box: access door	Carbone/epoxy		Autoclave issued from the top panel
Leading edge with local erosion protection (Cu-Ni)	Carbone/epoxy	1m ²	Leading edge : 1 panel with bonded stiffeners (see figure 3). The erosion protection is made by electroplating
Elevator surface and TE access doors	TBD	1.60m ²	
TE hinge fittings/bearings			
Wing Tip	Carbone/epoxy	0.5m ²	Autoclave – could be sandwich structure
Gaster Bump	Carbone/epoxy or aluminum		The process will be confirms once the design and the material defined. <i>This is the interface between the area of measurement and the attachment area.</i>
Others parts			
1 Mechanical actuator	TBD		Must be screw jack compatible with wind tunnel
2 fitting	Metal		
Screws, fastening,...			
Setting parts			
Root-to-wind tunnel interface			
Test features			
Pressure taps			
Interchangeable patches			

All parts shall be delivered with protection scheme defined in the WP1.

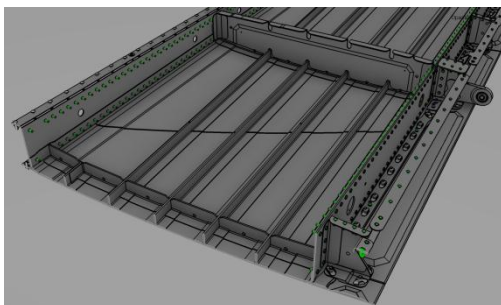


Figure 4: Example of bottom panel design

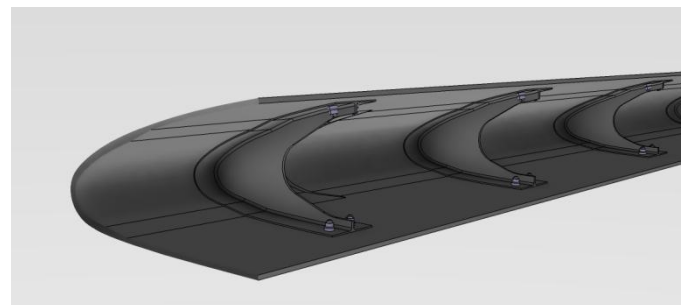


Figure 5: Example of leading edge design

Then, the handling system shall take into account of the facility used for aerodynamic tests. All the wind tunnel requirements will be supplied to the Applicant. The figure below shows the HTP demonstrator mounted in the test section of the wind tunnel.

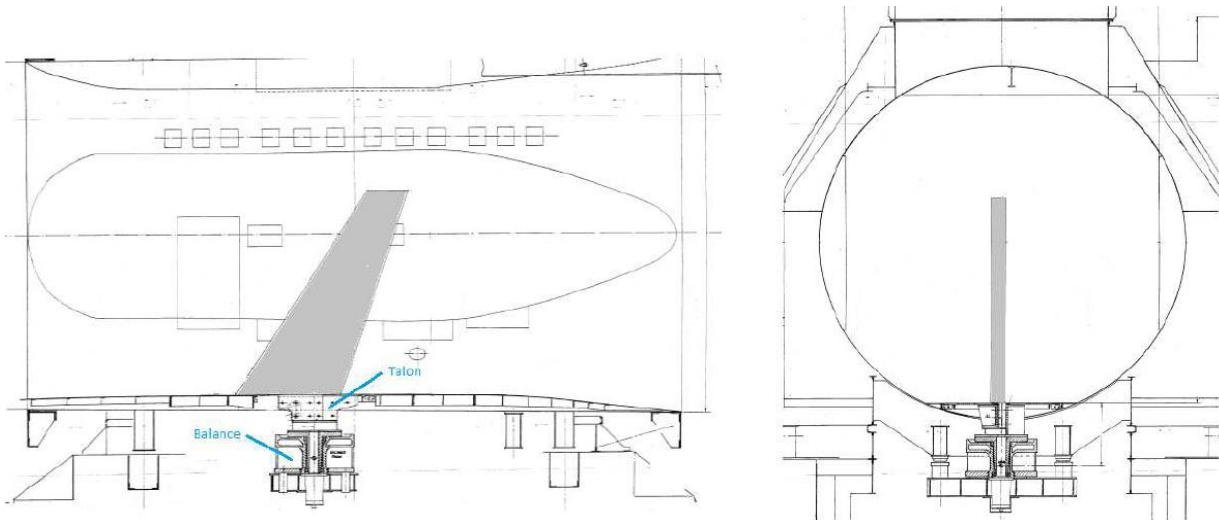


Figure 6: HTP demonstrator mounted in the wind tunnel test section

2.4. Instrumentation tasks – WP3

The applicant shall define within the WP1.1. the best way to equip the demonstrator with around 60 pressure ports from the leading edge to the trailing edge of the torsion box on the upper and lower surface distributed on two sections along the wind direction.

The positioning of holes for the pressure ports will be defined at the beginning of this project and after the architecture and conceptual phase (WP1.1.) to take into account all the manufacturing constraints.

The applicant must prove by preliminary tests of specimens that the technical solutions for the pressure ports is compatible with the requirements to be suitable for future laminar test. The requirements will be provided by the TM.

The applicant have to equip the demonstrator with the pressure pipes and connectors compatible with the wind tunnel requirements.

2.5. Assembly tasks – WP4

All the sub-assembly shall be performed by the applicant (TB, FLE, TE).

All the sub assembly will be checked dimensionally. At the end of manufacturing of each sub assembly, the applicant and the TM team will do a final control revue.

The assembly procedure of HTP will be provided by the applicant to the TM.

The final assembly of the HTP demonstrator will be performed by the TM team using the jig assembly defined and manufactured by the applicant. The final assembly will be performed with the assistance of the applicant.

The Installation procedure of HTP in the wing tunnel will be provided by the applicant to the TM.

The final protection scheme will be applied by the TM team.

The applicant should also plan a support phase to the Wind Tunnel Test preparation, at the test facility (Instrumentation and assembly, one person during maximum two weeks), to take place at the end of the project, to be confirmed after analysis of results reached at completion of the demonstrator.

2.6. List of the tasks

The following tasks are to be performed by the Partner:

Tasks		
Ref. No.	Title - Description	Due Date
T0	MANAGEMENT OF THE PROJECT	
T.1.1	ARCHITECTURE AND CONCEPTUAL PHASE	M1
T.1.1.1.	Airframe package Proposal update	
T.1.1.2.	Preliminary layout design for installation of system (pipes, wiring, equipment)	
T.1.1.3.	Airframe package structural analysis	
T.1.1.4.	Airframe package system analysis	
T.1.1.5.	Airframe package Finite Element Models	
T.1.1.6.	Systems analysis of system in interface with airframe package	
T.1.1.7.	Airframe package preliminary design : interfaces with other packages, structure architecture layout, design principles	
T.1.1.8.	Airframe package preliminary definition data : technical descriptions, drawings, 3D models, protection schemes, Interface control documents relative to the Airframe package (with other WP)	
T.1.1.9.	Airframe package Master Geometrical Model definition (MGM)	
T.1.1.10.	Airframe package preliminary digital mock-up	
T.1.1.11.	Airframe package weight and balance status	
T.1.1.12.	Selection of materials, standard parts, protection, fasteners	
T.1.1.13.	Selection of manufacturing processes	
T.1.1.14.	Airframe package test instrumentation requirements	
T.1.1.15.	Design qualification plan	
T.1.1.16.	Substantiation tests definition	
T.1.2.	DETAILED DESIGN PHASE	M2
T.1.2.1.	Airframe package detailed design	
T.1.2.2..	Detailed layout design for installation of system (pipes, wiring, equipment)	
T.1.2.3.	Airframe package detailed digital mock-up	
T.1.2.4.	Detailed pipe & wiring design	
T.1.2.5.	Airframe package weight and balance status	
T.1.2.6.	Airframe package test instrumentation definition	
T.1.2.7.	Acceptance procedure	
T.1.2.8.	Airframe package definition data : technical descriptions, drawings, 3D models, ICD relative to other Work packages	

T.1.2.9.	Strength substantiation (static and fatigue)	
T.1.2.10.	Dynamic analysis (flutter analysis, etc)	
T.1.2.11.	Substantiation tests results	
T2	MANUFACTURING	
T2.1	Supplying of raw material (composites and metal materials)	M2-5months
T2.2	Manufacturing of each single parts of HTP demo	M2+2months
T2.3	Acceptance revue of each sub-components	M2+3months
T3	INSTRUMENTATION	
T3.1	Pressure taps	M3
T4	ASSEMBLY	M3
T4.1	Acceptance revue of jig assembly and assembly procedure	M3
T4.2	Support for the final assembly	M3+3 months
T4.3	Support for the wind tunnel tests preparation	M3+5 months

3. Major deliverables/ Milestones and schedule (estimate)

Outputs			
Ref. No.	Title - Description	Type	Due Date
	Engineering outputs		
O1.1.	Airframe package Detailed Technical Specification	Document	M1 & M2
O1.2.	Justification Plan	Document	M1 & M2
O1.3.	Airframe package digital mock-up (outline drawings and models)	CAD files	M1 & M2
O1.4.	Airframe package Preliminary design file (PDF) : 2D drawings definitions	Document	M1
O1.5.	Detailed design file (DDF)	Document + CAD	M2
O1.6.	Layout assembly drawings	Document	M1 & M2
O1.7.	Detailed installation of systems	Document + CAD	M2
O1.8.	Interface Control Documents (with all other packages)	Document	M1 & M2
O1.9.	Interface Control document list	Document	M1 & M2
O1.10.	Engineering Bill of material	CAD	M1 & M2
O1.11.	Airframe package design breakdown list	Document	M1 & M2
O1.12.	Interchangeability drawings	Document	M1 & M2
O1.13.	System installation manufacturing drawings design for installation of system (pipes, wiring, equipment, mechanisms)	Document + CAD	M1 & M2
O1.14.	Inertia status (including hinge rotation inertia)	Document	M1 & M2
O1.15.	Equilibrium diagram on main structural element	Document	M1 & M2
O1.16.	Sizing sheets	Document	M1
O1.17.	Substantiation forms	Document	M2
O1.18.	Low clearance drawings (with minimum distance allowed)	Document	M2
O1.19.	System analysis (doors, mechanism)	Document	M1 & M2
O1.20.	Safety Analysis (including jamming analysis)	Document	M1 & M2
O1.21.	Dynamic analysis	Document	M1 & M2
O1.22.	Airframe package test program	Document	M1 & M2
O1.23.	Airframe package substantiation test Procedures	Document	M1 & M2
O1.24.	Tests reports	Document	M2
	Manufacturing Outputs		
O2.1.	Single parts acceptance	Meeting + document	M2+3months

Outputs			
Ref. No.	Title - Description	Type	Due Date
O2.2.	Sub-assembly (HTP Main box, leading edge, elevator) and control acceptance	Hardware	M3
O2.3.	Assembly jig		M3
O2.4.	Instruction sheet of the assembly in the wind tunnel	document	M3
O2.5	Installation procedure of HTP demonstrator in the wing tunnel	document	M3

Deliverables			
Ref. No.	Title - Description	Type	Due Date
D1.1	PDR	Meeting	M1 & M2
D1.2.	CDR	Document	M1 & M2
D2.1.	Single parts acceptance	Meeting + document	M2 + 3 months
D2.2.	Manufacturing acceptance	Meeting	M3

Milestones (when appropriate)			
Ref. No.	Title - Description	Type	Due Date
M0	Kick Off Meeting / Launch Design Review KOM/LDR	Meeting	T0
M1 prelim	Preliminary Design Review (PDR)	Meeting	T0+5 months
M1	Closure of PDR	Meeting	T0+6 months
M2.0	supplying of raw material and first tooling design and jig design	Document	T0+7months
M2 prelim	Critical Design Review (CDR)	Meeting	T0+11 months
M2	Closure of CDR	Meeting	T0+12 months
M3	Acceptance of the manufacturing of the HTP demonstrator	Hardware +Document	T0+18 months

Tasks	Title - Description	Year 1												Year 2										
		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23
T0	Management																							
T1.1	Architectural and conceptual phase																							
T1.2	Detailed definition phase																							
T2	Manufacturing																							
T3	Instrumentation																							
T4.1	Sub Assembly																							
T4.2	Support for the final assembly																							
T4.3	Support for the wind tunnel tests preparation																							
	Wind tunnel tests (No task, just for information)																							

4. The Applicant Mission and IPR's

The mission of the applicant will be to collaborate with the TM team in the design and the manufacturing of a laminar HTP. The TM will provide the adequate informations to enable the Applicant to be responsible of its



work package. Further innovations and improvements and recommendations from specific studies and analysis proposed by the Applicant will be welcomed.

All the information and data to be exchanged between the TM and the Beneficiary of this CfP will be regulated under specific NDA and IPR regulations that will recognise mutually their property following the recommendations and directives of the CS JU.

5. Special skills, Capabilities, Certification expected from the Applicant(s)

- The applicant shall have a large experience in designing, sizing airframe parts for the aeronautical industry, in particular large composite parts. (carbon fiber and epoxy resin)
- The applicant shall comply with the TM procedures concerning airframe design and manufacturing. These procedures will be provided in the requirement document to be issued during the negotiation phase.
- The applicant shall be proficient in using CATIA V5 R20 software (Design modules in particular).

The following manufacturing skills and equipment are required:

- Strong knowledge on thermoset composite material with reinforced fibres,
- Strong knowledge on aeronautical assembly technologies (metallic and composite materials),
- Proven experience and capabilities in the realization of manufacturing studies

IV. Design, test and manufacturing of robust fluidic actuators

Type of action (RIA or IA)	RIA		
Programme Area	LPA Platform 1		
Joint Technical Programme (JTP) Ref.	WP1.5		
Indicative Funding Topic Value (in k€)	350 k€		
Duration of the action (in Months)	36 months	Indicative Start Date ⁴	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-LPA-01-07	Design, test and manufacturing of robust fluidic actuators
Short description (3 lines)	
Design, test and manufacturing of robust, energy-efficient, aerodynamically effective actuators without moving parts for wind tunnel testing and aircraft-scale ground testing.	

⁴ The start date corresponds to actual start date with all legal documents in place.

1. Background

The desire for more ecologic and more economic turbofan engines in civil aviation leads to increasing “Bypass Ratios” (BPR) and lower “Fan Pressure Ratios” (FPR). Associated with both are larger fan diameters along with larger engine nacelles. With increasing nacelle size, the engine integration under the wing of current conventional aircraft under development is already challenging but becomes even more when novel aircraft configurations are considered, featuring highly integrated Ultra High Bypass Ratio (UHBR) engines.

This challenge is driven by two aspects: Firstly, at high angles of attack and low speeds current conventional aircraft with under-wing mounted engines are susceptible to local flow separation in the region inboard of the wing/pylon junction. This separation is triggered by interfering vortices originating from the engine nacelle, the slat ends etc. Secondly, with larger engine nacelles it becomes more difficult to ensure sufficient clearance between the nacelle and the runway for the aircraft on ground. To evade longer landing gear struts suffering from weight and space penalties as well as an increased level of landing gear noise, the engine is closer coupled to the wing. The close coupling requires slat-cut-backs in the region of the wing/pylon junction in order to avoid clashes of the deployed slat with the nacelle. These slat-cut-backs further exacerbate the risk of the aforementioned separation.

Possible consequences are the degradation of the effect of movables and the reduction of maximum lift. The maximum lift coefficient for the landing configuration and the lift over drag ratio for the take-off configuration are directly related to the achievable payload or flight range. In current aircraft, the maximum local lift is significantly improved with strakes mounted on the inboard side of the engine nacelle. Yet, the aerodynamic effect of strakes is limited and for modern VHBR engines the problem of possible local flow separation persists, leaving further space for optimizing high-lift performance. With the upcoming introduction of highly efficient and ecologic UHBR engines, slat-cut-outs will likely become larger and the problem will even become worse.

To remedy this problem Active Flow Control (AFC) based on pulsed air blowing with net mass flux is applied at the engine-wing junction either at wing leading edge or at the engine pylon. The aerodynamic proof of concept will be given in wind tunnel test. This wind tunnel test will reflect fully realistic 3D flow conditions. After the wind tunnel test a real-scale ground test is envisioned to prepare future flight testing. The actual conduction of these tests is not part of this CfP, however the support of wind tunnel testing is expected.

2. Scope of work

In this application context the objective is to design, validate and manufacture robust, energy-efficient aerodynamically effective flow control actuators for unsteady air blowing with air net mass flux without moving parts. All related expertise, experiences and tools expected from the partner are stated in section 2.

The following tasks are to be performed by the Partner:

Tasks		
<i>Ref. No.</i>	<i>Title – Description</i>	<i>Due Date</i>
T1	Development, design, manufacturing and validation of actuators for wind tunnel testing	M6
T2	Support wind tunnel testing and analysis	M11
T3	Support development of integrated actuator solution from acoustics, structure, systems and aerodynamics point of view	M20
T4	Development, design, manufacturing and validation of full-aircraft scale actuators	M30

Task 1: Development, design, manufacturing and validation of actuators for wind tunnel testing

The applicant should develop, design and manufacture flow control actuators based on pulsed air blowing with net mass flux. The work will encompass different design loops. In a first loop actuation requirements will be provided by the existing Clean Sky2 consortium based on previous studies and based on the best current knowledge to the applicant. This specification will be updated and finalized in later loops based on the numerical aerodynamic studies carried out for the given application case: the engine/pylon junction of UHBR turbofans. This updated specification will be delivered by the topic leader to the applicant in time. The design of the actuators carried out by the applicant should be based on actuator experiments and state-of-the art numerical simulations. The applicant will explain in the proposal numerical tools that will be used for the simulations while justifying their suitability in this context. The applicant must align the final actuator design with the necessities given by the wind tunnel testing facility (interfaces, measurement techniques etc.) and wind tunnel model (installation, integration etc.). The applicant must characterize and validate the actuators in accordance with the given specification. Under what conditions (silent conditions, pressurized etc.) this validation testing has to take place will be discussed with the applicant. This proof must be clearly documented in the delivery report which is provided to the Wind Tunnel Testing (WTT) together with the final test actuators. For more details on actuator necessities please refer to section 2.

Task 2: Support wind tunnel testing and analysis

The aerodynamic wind tunnel testing is not in the scope of this proposal. Wind tunnel testing is planned

to take place via a separate Call for Tender (CfT) earliest Q3 2016 and latest Q2 2017. The applicant should attend all the relevant wind tunnel test to ensure the actuators are properly installed, to continuously monitor the actuator performance based on real-time measurement data and to realize possible modifications onsite if required. The applicant should further analyse and discuss the actuator performance in the context of the application wind tunnel testing. The task will be concluded with an actuator performance report with respect to the wind tunnel testing and input to a technology review.

Task 3: Support development of integrated actuator solution from acoustics, structure, systems and aerodynamics point of view

Aerodynamic performance indicated by the control authority is of course the key driver for actuators. However, for paving the way towards real aircraft applications an integrated actuator solution is required. The applicant should contribute to an integrated technology optimization loop. In this loop the existing Clean Sky2 consortium performs a multidisciplinary design exercise on flow control (acoustic, aerodynamics, system, structure etc. aspects). In this context the role of the applicant is to analyse and optimize the flow control actuator design to maintain the required actuator performance to fit into the multidisciplinary design approach.. Some design features already identified but not disclosed here will be studied in cooperation with other partners.

Task 4: Development, design, manufacturing and validation of full-aircraft scale actuators

To contribute to the next step towards real-aircraft applications, the applicant will develop, design, manufacture and validate full-aircraft scale actuators. A specification considering real-aircraft constraints and requirements will be given to the applicant covering all necessary aspects of actuator design. Harsh environment testing must be considered if the applicant has not studied this before this contribution and documented this aspect in the previous phases. Harsh environment is determined by the typical aircraft operation conditions (vibrations, icing conditions, saline atmosphere, artificial rain conditions, liquid contamination (anti-icing fluid, skydrol), dust/sand exposure, aircraft typical hot and cold temperatures). Besides the proof to withstand harsh environment conditions the applicant should validate the actuator with respect to aerodynamic performance. Validation should be documented in a final design report. The design documents will be handed over to aviation certified partner to manufacture the actuators for the final ground testing.

3. Major deliverables/ Milestones and schedule (estimate)

Ref. Nr.	Deliverable Title -	Type	Due date
D1	Wind tunnel actuator delivery report	Report	M6
D2	Report on actuator performance in WTT	Report	M11
D3	Study report on integrated actuator design solutions	Report	M20
D4	Delivery report for Ground Test Actuator-Hardware prototypes	Report	M25

Ref. Nr.	Milestone Title	Type	Due date
M1	Actuators meet specifications for WTT	Data	M5
M2	Actuators provided to WTT	Hardware	M6
M3	Actuators provided to flow control system pre-test (dedicated to ground tests)	Hardware	M24
M4	All design documents provided to partner having aviation certification	Data	M30

4. Special skills, Capabilities, Certification expected from the Applicant(s)

The applicant should have profound knowledge in flow control actuator design for aircraft applications. The actuator design must be based on pulsed air blowing with net mass flux. For robustness reasons actuators should have a low part count and mandatory no moving parts such as fast switching valves or similar. Before answering to this call the actuators must have been validated with respect to

A) their aerodynamic effectiveness in 3D flow conditions of aircraft applications under industrial relevant Reynolds numbers ($Re > 1\text{mio}$) and Ma numbers ($Ma > 0.18$)

B) their robust functionality under harsh environment conditions (rain, ice, vibration etc.).

For A) the applicant must give proof of having designed actuators with peak jet Mach numbers of at least 0.9, jet pulsation frequencies of between 20Hz and 300Hz and a mass flow per unit length of $270\text{g}/(\text{s}\cdot\text{m})$. Furthermore the applicant must show dedicated experience and expertise in designing actuator outlet slots with high aspect ratios, i.e. width to height of more than 10. The applicant must give proof that for the scenario of putting more than at least five actuators next to each other that the peak total pressure of any actuator outlet should not deviate by more than 2.5% from the mean peak jet total pressure.

B) would help the project/the EC to save development cost and time and is therefore strongly preferred.

The applicant should avail of the necessary design capabilities (actuator design, numerics and experiments) and numerical tools. Emphasis should be given on the capability to apply unsteady simulations to realistically investigate the flow field inside the actuator. The applicant does not need to be an aviation authority approved system supplier.

V. Drive and control system for piezoelectric AFC actuators - Ground Based Systems Demonstrator: Development, manufacturing and testing of a smart amplifier and control box for fluidic actuators with advanced monitoring capabilities

Type of action (RIA or IA)	RIA		
Programme Area	LPA Platform 1		
Joint Technical Programme (JTP) Ref.	WP1.5		
Indicative Funding Topic Value (in k€)	350 k€		
Duration of the action (in Months)	24 months	Indicative Start Date ⁵	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-LPA-01-08	Drive and control system for piezoelectric AFC actuators Ground Based Systems Demonstrator: Development, manufacturing and testing of a smart amplifier and control box for fluidic actuators with advanced monitoring capabilities
Short description (3 lines)	
For the qualification of AFC systems for application on the pylon wing junction, ground test (GT) and flight test (FT) campaigns will be performed. One essential part of such an actuator system is a drive and control unit that can be used to drive and control scale one actuator in a relevant environment during these test campaign. The development work is focusing on the actuator hardware control as well as the capability to integrate these systems in higher control levels.	

⁵ The start date corresponds to actual start date with all legal documents in place.

1. Background

Actuators for active flow control (AFC) are systems with powered mechanical elements enabling an unsteady manipulation of the airfoil's boundary layer. Such actuators need a special design which is in the present case of synthetic jet actuators and pulsed jet actuators a piezoelectric-based transducers concept.

Due to driving frequencies up to some kilohertz and the capacitive behavior of the piezoelectric transducers, these actuator systems can have unfavorable high power consumption, if the drive system is not adapted for these AFC actuator systems. Adapting these systems to aircraft level applications, the driving electronics need therefore to be very energy efficient and capable of being integrated into the actuation system itself, e.g. into, under or very close to the actuator hardware. In addition, the control as well as the monitoring of the devices shall be performed close to the actuators in order to minimize the amount of data that is needed to be transferred from a global control level to the local actuator control unit. The system shall also be capable to handle the power management of the actuators in order to control the actuators either resonant or non-resonant with a fixed or closed-loop controlled frequency. This also includes a power reduction and/or power recovery concept.

Activities to be performed by the applicant:

- Development and design of a drive and control system concept for piezoelectric-driven AFC actuators
- Development of a detailed design adapted to the space allocation for the installation close to a synthetic jet or a pulsed jet actuator system in the pylon wing junction region
- Development of a demonstrator (hardware) and manufacturing for a ground based demonstrator (GBD) (at least two fully equipped full scale systems shall be available for the tests)

For the qualification of AFC systems for application on the pylon wing junction, ground test (GT) and flight test (FT) campaigns will be performed. The development work within the work packages is focusing on the actuator hardware control as well as the capability to integrate these systems in higher control levels. One essential part of such an actuator system is a drive and control unit that can be used to drive and control scale one actuators in a relevant environment during a ground test campaign.

The system shall be capable to drive resonant and non-resonant piezoelectric AFC actuators in a performance range that is relevant for GT and FT application. The system shall include the following modules:

- drive module to drive piezoelectric actuator at application specific driving voltages, an integrated amplifier solution is preferred (e.g. integrated electronics, ASIC-based)
- control unit to provide the relevant signal (amplitude, signal form, frequency) for the actuators
- sensor data acquisition unit, that can handle the sensor data of one or a set of actuators to be able to control the actuator or even to enable health monitoring of the actuator during operation
- communication unit that can be used to drive and control the actuators remotely from a distance that is relevant in scale one or in a large scale W/T respectively.

2. Scope of work

The outcome of this topic will be the development, the manufacturing and the test of the smart amplifier and control box for fluidic actuators and sub-systems to enable final tests of the GBD. This will include but not be limited to the manufacture or procurement of:

1. Smart amplifier system; to be developed & tested
2. Actuator connection panel for a multiple number of single actuators
3. Option to implement control algorithms for AFC actuators
4. Open system parameters can be monitored by a smart device
5. Implementation of advanced monitoring interface system
6. Manufacturing and test of the whole box and subsystems
7. Delivery of two sets of boxes for Large Scale GT

The applicant will be supported by the Clean Sky 2 LPA partners providing the following information:

- Specifications on available actuators and their specification
- Specifications and details on space allocation
- Specification of the interface to higher control levels

Further conditions are that the system should meet the following conditions (preliminary actuator and system specifications):

- Capacitance of the piezoelectric transducer up to 200nF per single element
- Capability to drive and control >100 actuators (exact number of actuators will be defined during the definition phase in the first part of the project)
- Driving Voltage up to 200Vpp; preferably unipolar driven, optionally bipolar driven
- Driving Frequency up to 4kHz (depending on the application and the actuation concept)
- Minimal space allocation – an integrated solution should be preferred
- Minimal energy consumption or a concept to minimize the energy consumption of the system

As the actuators shall also be driven in a dusty or humid environment, the drive and control box shall be secured against these environmental impacts to meet the associated IEC standard. The applicant shall provide a number of drive and control units, that enough to drive two sets of fully equipped full scale GT benches. Certification of the equipment is not necessary, as the development shall be used in a GT for proof of concept. The height of the system should not exceed 200 mm, as it should be installed inside in W/T model.

Topic Work Breakdown Structure of Active Control Demonstration:

- WP1 - a drive and control system concept
- WP2 - Development of a demonstrator (hardware) and manufacturing
- WP3 - Lab testing with actuators

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
Del.1	Smart Amplifier Box (SAB) concept	Report	M3
Del.2	Smart Amplifier Box (SAB) detailed design	Report	M8
Del.3	Annual Review	Meeting	M12
Del.4	Interfaces Agreed; Implementation specification sheet and Drawings delivered	Report	M15
Del.5	Assembly and Implementation report	Report	M19
Del.6	Test/Deviation reports/Final Report and delivery of components	Report / Hardware	M24

Milestones		
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Due Date</i>
M1	SAB Design Review	M8
M2	SAB Integration Review	M15
M3	Hardware Delivery	M24



4. Special skills, Capabilities, Certification expected from the Applicant(s)

- The applicant should have expertise in the area of development of power electronics for piezoelectric AFC actuators
- The applicant should have expertise in the area of ASIC solutions or integrated electronics as an integrated power supply solution should be preferred
- The applicant should have expertise in the field of Sensor- and Embedded Electronics as well as Integrated High Voltage Electronics

VI. Test Aircraft Preparation and Qualification for Scaled Flight Testing

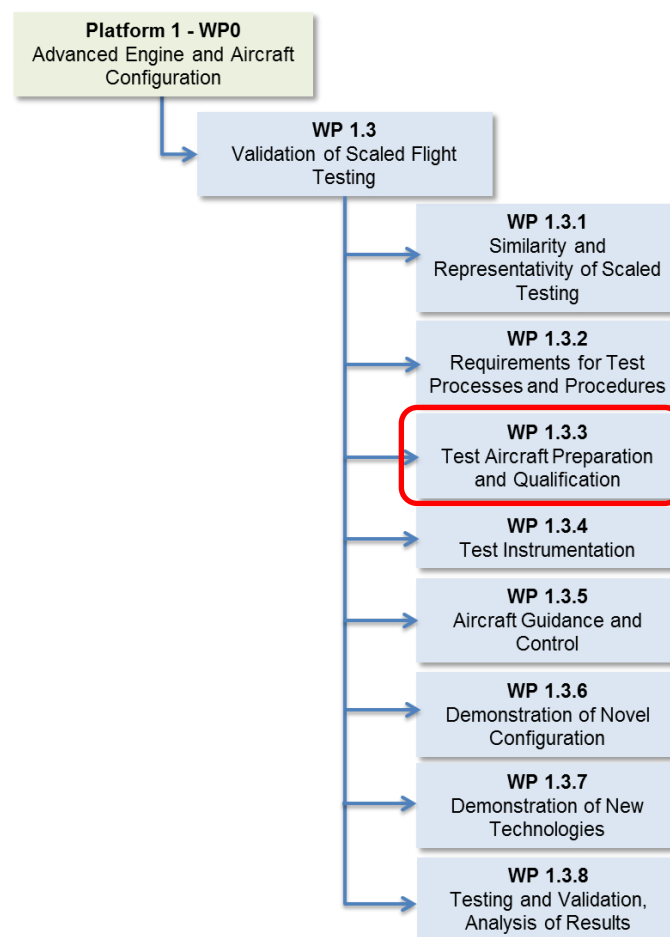
Type of action (RIA or IA)	IA		
Programme Area	LPA		
Joint Technical Programme (JTP) Ref.	WP 1.3 – Validation of Scaled Flight Testing		
Indicative Funding Topic Value (in k€)	2000 k€		
Duration of the action (in Months)	48 months	Indicative Start Date⁶	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-LPA-01-09	Test Aircraft Preparation and Qualification for Scaled Flight Testing
Short description (3 lines)	
This task will cover development activities for a scaled flight testing platform, incorporating know-how and results available in the frame of other R&D studies carried out by the partner. This will include the definition of the vehicle and of its modifications compared to an already existing baseline, and the qualification of the modifications and the complete vehicle.	

⁶ The start date corresponds to actual start date with all legal documents in place.

1. Background

The overall intention of work package 1.3 is the systematic proof of scaled flight testing as viable means to mature and validate new aircraft technologies and aircraft configurations to high levels of technology readiness and the representativeness of the results for full-scale vehicles. This includes the evaluation of the reliability and quality of this mean, including the definition of a principle set of standard rules and procedures for all contributing elements as well as the quality of the equipment and measurement instrumentation. The modular design of the vehicle intended to use for the test provides the favourable opportunity of conducting related tests with different major components, such as wings, rear fuselage, engines including engine positions which clearly contribute to cost efficiency and flexibility of testing and the multi-purpose-use of the flight test vehicle.



The objective of this dedicated topic is mainly to work in WP1.3.3 on the the test vehicle preparation and qualification.

Additional contributions for this topic are seen in the transversal WP1.3.1 on similarity of scaled testing and 1.3.2 on the requirements for test processes and procedures. Also, a contributing role to the overall scientific validation of the technology is seen.



The requirements and architecture of the flight test vehicle will be based on input from WP1.3.2. Ideally, the partner should have access to a test vehicle suitable for Dynamically Scaled Flight testing for a large Passenger Aircraft. To minimize gust impact, the vehicle should have a mass in the region of 150kg and provide installations to vary mass and inertias.

This test vehicle should be modified or enhanced to the requirements provided in the project, prepared, qualified and put into flight testing (1.3.8). This work should be done in close collaboration with WP1.3.5 on the guidance system and 1.3.4 on the test instrumentation. It is assumed that from flight testing some additional modifications will result, which should be implemented.

As the topic is aimed to validate a new technology for flight physics testing and understand of the background theory is required, the topic manager is looking for a partner or partner consortium with experience in R&D. For this partner a leading role in the WP1.3.3 is foreseen, managing the contributions from other partners and from subcontracts. The responsibility for vehicle modifications against the overall workpackage lead (WP1.3) is placed in this task.

2. Scope of Work

The following tasks are to be performed by the partner:

Tasks		
Ref. No.	Title – Description	Due Date
T1	Prepare test aircraft software, flight control laws	T0+48
T2	Update/modify test aircraft for sensitivity studies	T0+45
T3	Calibrate and Qualify Test Aircraft Systems	T0+31
T4	Build novel components	T0+48

Task-1: Prepare test aircraft software, flight control laws

Under this task, the test aircraft software, including the flight control laws, is to be updated and prepared for the flight tests.

The test aircraft software controls all functions of the aircraft, including the flight control laws. Further functionality includes the control of the propulsion systems, the recovery system, further functionalities of the vehicle like the trailing edge flaps and the interfaces to the instrumentation and other payloads.

Task-2: Update/Modify Test Aircraft for Sensitivity Studies

It is expected that after the first test flights and measurements the test aircraft has to be modified to properly perform the sensitivity studies. Furthermore, it is expected that for these studies the properties of the test vehicle have to be modified in a sensible way, to meet similitude requirements.

For this task a close collaboration with the other work packages is required, at the end of which the required physical changes to the test aircraft have to be defined. The required modifications to the vehicle have to be designed, built and the modified vehicle properties have to be recorded.

Task-3: Calibrate and Qualify Test Aircraft Systems

Under this task the assembled test vehicle is to be calibrated and qualified. This includes the identification of vehicle mass properties, as required for the validation of Scaled Flight testing. Furthermore this includes the qualification of installed vehicle on-board systems (as covered under task T1) as well as the qualification of installed systems such as the instrumentation and the guidance system. The qualification has to be documented and the cleared vehicle is then flight tested.

The qualification of the vehicle and the installed systems is to be performed against specifications from WP1.3.1/2 and others.

Task-4: Design and Build Novel Parts

In this task, from specifications defined in WP1.3.1 and WP1.3.2, the required parts for the test vehicle for Scaled Flight Testing are to be designed and built. These parts are either required to bring the model up to the required status for the initial test or to implement novel configurations or new technologies.

This includes both structural parts, such as wings and fuselage, as well as vehicle systems, such as landing gear, electrical and recovery systems. Some systems, like the propulsion system, are likely to be purchased and only to be integrated. The vehicle also includes specialized features such as mountings for wind tunnel tests.

CAD data for the model can be provided to the partner for this task.

Under this task also the integration of systems developed in different parts of WP1.3 is to be performed, such as the instrumentation system and the guidance system.

An additional task is the design and implementation of specific Scaled Flight Testing design features to influence the vehicles mass properties.

Task-3: Update/Modify Test Aircraft for Sensitivity Studies

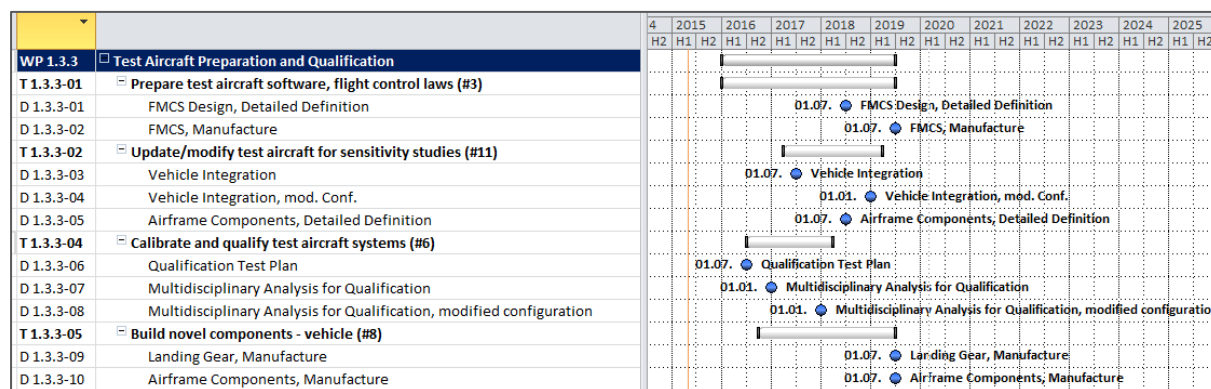
It is expected that after the first test flights and measurements the test aircraft has to be modified to properly perform the sensitivity studies. Based on first flight test results for the dynamics of the test aircraft, its mass properties may have to be adjusted.

For this task a close collaboration with the other work packages is required, at the end of which the required physical changes to the test aircraft have to be defined. The required modifications to the vehicle have to be designed, the modified components have to be built and the modified vehicle properties have to be recorded.

3. Major Deliverables/Milestones and Schedule (Estimate)

Deliverables			
Ref. No.	Title – Description	Type	Due Date
D-01	FMCS Design, Detailed Definition	Doc	T0+36
D-02	FMCS, Manufacture	HW	T0+48
D-03	Vehicle Integration	HW	T0+24
D-04	Vehicle Integration, Modified Configuration	HW	T0+42
D-05	Airframe Components, Detailed Definition	Doc	T0+36
D-06	Qualification Test Plan	HW	T0+12
D-07	Multidisciplinary Analysis for Qualification	Doc	T0+24
D-08	Multidisciplinary Analysis for Qualification, Modified Configuration	Doc	T0+18
D-09	Landing Gear, Manufacture	HW	T0+48
D-10	Airframe Components, Manufacture	HW	T0+48

Milestones (when appropriate)			
Ref. No.	Title - Description	Type	Due Date
M 1.3.0-02	Test A/C ready	Activity	T0+12
M 1.3.0-03	First Flight	Activity	T0+15
M 1.3.0-04	1st Flight Test Campaign Completed	Activity	T0+24
M 1.3.0-05	CDR	Doc	T0+36
M 1.3.0-06	2 nd Flight Test Campaign Completed	Activity	T0+48
M 1.3.0-07	Final Report	Doc	T0+54



4. Special Skills, Capabilities, Certification Expected from the Applicant(s)

It is required for this work package to possess experience in design, building and testing of scaled flight test



vehicles (weight class 150kg). A further specialization for vehicles for dynamically scaled flight testing for Large Passenger Aircraft is required. Dynamically scaled testing means that the vehicles are scaled in their dynamics (mass, inertia) in addition to the geometric scaling, and is a key topic within WP1.3.

As some components of the vehicles are to be contributed by other partners and subcontracted, skills in partner management are required.

Required skills:

- Design of vehicles for Dynamically Scaled Flight Testing (Large Passenger Aircraft)
- Management of building phase
- Contribution to the building, for certain components
- Vehicle and on-board systems qualification
- Flight physics understanding of Dynamically Scaled testing

Previous experience in similar research projects would be beneficial.

VII. Hybrid Propulsion Demonstrator Components – Electric Power Drives

Type of action (RIA or IA)	IA		
Programme Area	LPA		
Joint Technical Programme (JTP) Ref.	WP1.6.2 Demonstration of Radical Aircraft Configurations		
Indicative Funding Topic Value (in k€)	1500 k€		
Duration of the action (in Months)	48 months	Indicative Start Date⁷	Q2 2016

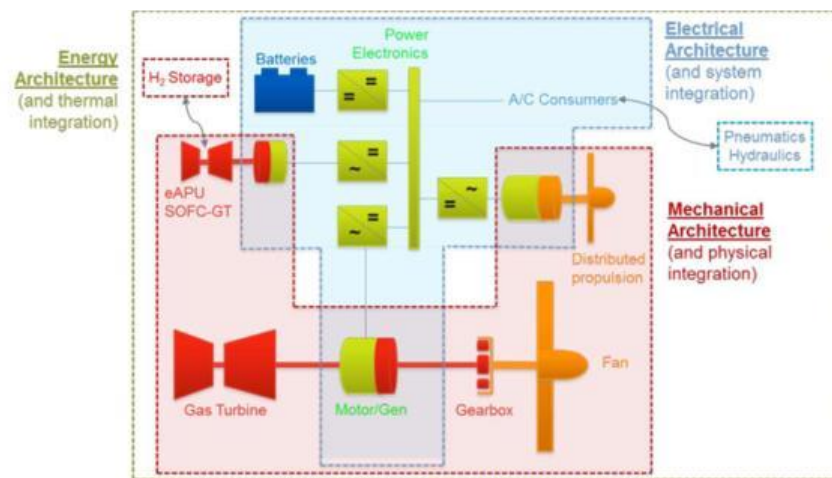
Identification	Title
JTI-CS2-2015-CFP02-LPA-01-10	Hybrid Propulsion Demonstrator Components – Electric Power Drives
Short description (3 lines)	
Development of Electric Drives components for a Hybrid Electric Propulsion system. This covers the design, build and test of specified components and their integration into a demonstrator test bench. In addition, suitable modelling and simulation modules for these components are to be provided.	

⁷ The start date corresponds to actual start date with all legal documents in place.

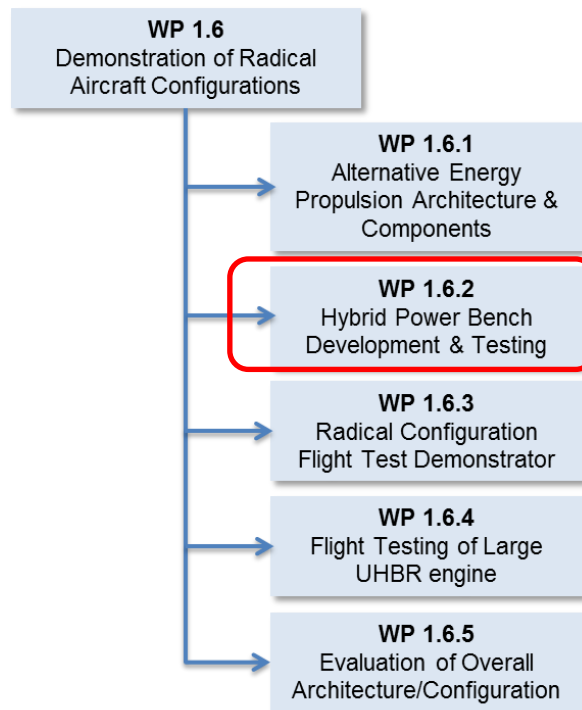
1. Background

The activities in this work package will lead up to the end of 2019 decision including the demonstration of novel propulsion concepts. The overall aircraft architecture will be a result of the opened design space, i.e. of the hybrid propulsion architecture.

Within WP 1.6.1/2 basically four activities will converge to a validated concept; of these two are to be addressed within this topic:



- Based on the conceived architecture, definition and layout of the best suited crucial components and subsystems of the hybrid power train, namely in the areas of energy storage, motors, power distribution, power control, specific aircraft interfaces.
- Necessary hardware demonstration on systems level: Build and operate a hybrid power bench to test single components as well as the integrated power chain to confirm overall aircraft design assumptions and to validate concept feasibility, leading to the required input for systems design for flight test.



The main objective of this topic is to work in WP1.6.2 on the Hybrid Power Bench Development & Testing, for Electric Drive Components.

‘Electric Drives’ means this component includes electric machines (generators, motors) as well as any necessary gear component to deliver the required torque and speed. The component also includes any electronics needed for control and steering, but not the overall aircraft power management.

It is planned to test several consecutive cycles of components (generations) with increasing powerlevel and complexity.

2. Scope of work

Tasks		
Ref. No.	Title - Description	Due Date
T-1.6.2.2.2-02	Generator	T0+48
T 1.6.2.2.5-02	Electric Motor	T0+48

The subject of this call are several generations of electric drives (generators, motors), addressing different aspects:

- Design
- Modelling and Simulation Modules
- Build (Manufacture & Integration)
- Test
- Support

The drives are to be connected with other components, supplied by other partners in WP1.6, on a demonstrator test bench for Hybrid Electric propulsion.

A) Technical characteristics

It is planned to test several consecutive cycles of components (generations) with increasing power level and complexity. The first machine to be investigated will be a lightweight design based on state of the art technology at a power level of several hundred kW. In further generations, technologies and motor topologies are to be designed and tested that will enable airworthy electric machines with a specific power of at least 5 kW/kg in an intermediate timeframe (TRL6 in 2025), and 10 kW/kg as a long-term target (TRL6 in 2035).

B) Interfaces with the test bench (HGD, Hybrid Ground Demonstrator)

Electric power (three phases, 540V) cold water and pneumatic connections are available in the test hall. For later generations electric machines a higher voltage supply is envisaged. Further interface details will be provided in due time as the next envisaged test bench stages will be defined.

C) Electric drives systems supplied through this CfP will include

The equipment expected for this WP is in three different categories:

- Novel component Electric Generators Drives – to be driven either from a power source (piston engine or gas turbine) or by an electric drive simulating the power source
- Novel component Electric Motor Drives – to drive a propulsor or an electric propulsor load simulator
- Conventional Electric Drives to simulate power generation and loads

Each of the components has to include the following:

- For the components 'Drive' any combination of electric motor and gearbox to obtain the specified speed and torque fully controlled from the control room, or – vice versa – acting as a generator to provide electric power converted from a mechanical input
- Mechanical interfaces to other components of the test bench
- System support frame
- Electronics & control software to control these components and to provide the connection to an overall power management system
- Ancillaries such as lubricating/cooling system
- Provision to connect existing speed and torque measuring systems of the test bench
- The control system has to provide torque and speed modes, torque has to be provided from 0 rpm on.
- The components have to be remotely controlled from the separate control room.
- Power switching is to be included
- Safety features such as emergency push button and galvanic isolation of sensor lines have to be provided.
- Monitoring of the machines state through for example vibration and temperature measurement, as suggested by the applicant

Documents:

- Detailed documentation (detailed description, operations, protocols)
- Safety analysis
- Electrical and mechanical interfaces drawings
- Maintenance procedures

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type	Due Date
	(+ intermediate component generations as required)		
D 1.6.2.2.2-04	Concept HGD 2.0 Generator	Doc	T0+6
D 1.6.2.2.2-05	Initial HGD 2.0 Generator Specification	Doc	T0+12
D 1.6.2.2.2-06	Final HGD 2.0 Generator Specification	Doc	T0+30
D 1.6.2.2.2-07	Final HGD 2.0 Generator Design	Doc	T0+33
D 1.6.2.2.2-08	Final HGD 2.0 Generator System	HW/SW	T0+36
D 1.6.2.2.5-04	Concept HGD 2.0 Propulsor System	Doc	T0+6
D 1.6.2.2.5-05	Initial HGD 2.0 Propulsor System Specification	Doc	T0+12
D 1.6.2.2.5-06	Final HGD 2.0 Propulsor System Specification	Doc	T0+30
D 1.6.2.2.5-07	Final HGD 2.0 Propulsor System Design	Doc	T0+33
D 1.6.2.2.5-08	Final HGD 2.0 Propulsor Generation System	HW/SW	T0+36

Milestones (when appropriate)			
Ref. No.	Title - Description	Type	Due Date
M-1.6-4	[Contribution to] Power bench pre-tested	Doc	T0+36
M-1.6-5	[Contribution to] Power bench fully tested	Doc	T0+42
M-1.6-6	[Contribution to] Architecture converged	Doc	T0+48

WP 1.6.2	Hybrid Power Bench Development & Testing	
WP 1.6.2.2	Component & System Development	
WP 1.6.2.2.2	Power Generation	
T 1.6.2.2.2-02	Generator	
D 1.6.2.2.2-04	Concept HGD 2.0 Generator	01.09. ▼ Concept HGD 2.0 Generator
D 1.6.2.2.2-05	Initial HGD 2.0 Generator Specification	03.04. ▼ Initial HGD 2.0 Generator Specification
D 1.6.2.2.2-06	Final HGD 2.0 Generator Specification	01.01. ▼ Final HGD 2.0 Generator Specification
D 1.6.2.2.2-07	Final HGD 2.0 Generator Design	01.04. ▼ Final HGD 2.0 Generator Design
D 1.6.2.2.2-08	Final HGD 2.0 Generator System	01.07. ▼ Final HGD 2.0 Generator System

WP 1.6.2	Hybrid Power Bench Development & Testing	
WP 1.6.2.2	Component & System Development	
WP 1.6.2.2.5	Thrust Generation	
T 1.6.2.2.5-02	Electric Motor	
D 1.6.2.2.5-04	Concept HGD 2.0 Propulsor System	01.09. ▼ Concept HGD 2.0 Propulsor System
D 1.6.2.2.5-05	Initial HGD 2.0 Propulsor System Specification	03.04. ▼ Initial HGD 2.0 Propulsor System Specification
D 1.6.2.2.5-06	Final HGD 2.0 Propulsor System Specification	01.01. ▼ Final HGD 2.0 Propulsor System Specification
D 1.6.2.2.5-07	Final HGD 2.0 Propulsor System Design	01.04. ▼ Final HGD 2.0 Propulsor System Design
D 1.6.2.2.5-08	Final HGD 2.0 Propulsor Generation System	01.07. ▼ Final HGD 2.0 Propulsor Generation System

4. Special Skills, Capabilities, Certification expected from the Applicant(s)

For this topic it is required to have capabilities in the design, implementation and testing of electric drives. Electric drives means in this context electric machines (generators, motors), gears as required and the required electronics to steer and control the component. The applicant has to have the skill to design and integrate these components for application in aircraft propulsion systems and to provide the required interfaces to other components as well as to ancillaries such as the cooling system. The power level required in this project is 4MW and beyond. The applicant should have some insight into aerospace application of such components.

The proposal should include:

- Detailed study of the solutions
- Provision of technical data for simulation of the test bench design
- Manufacturing/Integration of the system
- Integration into the HGD and commissioning
- Support, maintenance and repairs for the bench tests of the complete system

The systems should be innovative for aerospace propulsion application, either by solution, technology or materials. The applicant may for example explore fields like:

- Mass optimization
- Overall efficiency
- Fault tolerance
- Operation at high altitude
- Integration with other functions (structure, systems)
- Omission of other components in the system (for example 'Electric Gearbox')

The applicant is required to have previous experience in the aerospace application of such systems. Part of the component work may be done by further partners or subcontracted, the applicant has to have the management skill to lead such work.

VIII. Hybrid Propulsion Component Studies – Electrics

Type of action (RIA or IA)	RIA		
Programme Area	LPA		
Joint Technical Programme (JTP) Ref.	WP 1.6.2 – Demonstration of Radical Aircraft Configurations		
Indicative Funding Topic Value (in k€)	1500 k€		
Duration of the action (in Months)	60 months	Indicative Start Date⁸	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-LPA-01-11	Hybrid Propulsion Component Studies – Electrics
Short description (3 lines)	
This task supports the Hybrid Electric Propulsion demonstration with component and architecture simulations, modelization of basic principles and break-through innovation. The focus is on electric generation, conversion and drive components.	

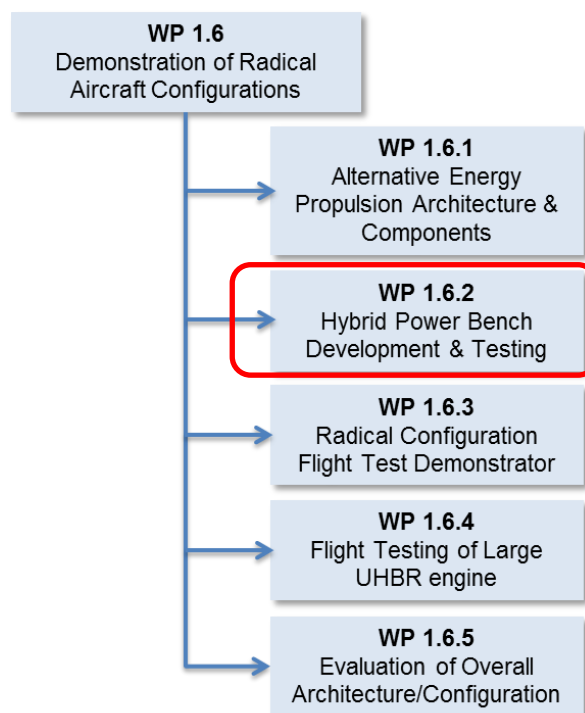
⁸ The start date corresponds to actual start date with all legal documents in place.

1. Background

The activities in this work package will lead up to the end of 2019 decision including the demonstration of novel propulsion concepts. The overall aircraft architecture will be a result of the opened design space, i.e. of the hybrid propulsion architecture.

This topic should mainly support one of the four main activities in WP1.6.2, as follows:

‘Based on the conceived architecture, definition and layout of the best suited crucial components and subsystems of the hybrid power train, namely in the areas of energy storage, motors, power distribution, power control, specific aircraft interfaces.’



This topic should support the work in WP1.6 with dedicated, specialized contributions for the preliminary design and simulation of electric drives, transmission and heat management components, as well as the overall electric system. As the power level involved is to be increased significantly for electric propulsion, it is expected that new solutions for technology and architectures have to be employed. For de-risking of the demonstration, extended simulation capabilities should be provided under this topic. As Hybrid Electric technology is a rapidly evolving field of research, the topic should also enable the rapid demonstrations of break-through technologies. The topic manager is looking for a partner with R&D experience, which could be a consortium of capable partners.

2. Scope of work

Tasks		
Ref. No.	Title – Description	Due Date
T 1	Development of a target setting tool for electrical machines	T0+48
T 2	Development of a tool for the estimation of Power Electronics performance	T0+48
T 3	Electric machines cooling system technology forecast	T0+48
T 4	Preliminary Design of Heat Exchanger System	T0+48
T 5	Impact of Partial Discharge on Design	T0+48
T 6	Optimization of Overall Electrical System	T0+60

A brief description of the specific requirements for the tasks is given below:

Task-1 Development of a target setting tool for electrical machines

In WP1.6 the demonstration of large electrical machines for a Hybrid Electric Propulsion system is planned. For the specific power of electric machines an intermediate target is seen for 5kW/kg in 2025, a long term target is seen for 10kW/kg in 2035. These targets are to be demonstrated by hardware contributed by partners in a different call for WP1.6.

Under this task an analytical tool is to be developed to estimate if these development targets can be achieved. It's expected that the progress will come in part from continuous development, for example material improvements, and from step changes, for example architecture changes or other break-through improvements.

Such a target setting tool is seen necessary for the project to understand the performance of the hardware components to be tested in the propulsion system demonstration.

A first version of the tool is to be calibrated against the first hardware tests run on the demonstrator test bench in 2017. Further version of the tools are required in line with following test campaigns in 2019 and 2021.

Task-2 Development of a tool for the estimation of Power Electronics performance

In relation to Task 1, under this task a tool for the estimation of the performance of power electronics for a Hybrid Electric Propulsion system is to be developed.

For Hybrid Electric Propulsion systems, the power electronics have to handle much higher power levels than in existing systems. As a way to improve the specific weight of the electric system, higher operating voltages are expected – this could require the switch to different materials and architectures for the power electronics.

Under this task, it's envisaged to develop an analytical tool to estimate the performance of different approaches to Power Electronics for a Hybrid Electric Propulsion system. From the results of the first demonstrators test runs in 2017 it's expected to be able to perform a calibration of the tool, with the final version of the software to be ready in 2019.

Task- 3 Electric machines cooling system technology forecast

Even with high efficiencies electric machines and components are generating substantial amount of (waste) heat. An efficient cooling of the machines is required to reach the high power level required. Adversly, the weight of the cooling systems affects the specific weight of the overall system, so that a light solution is sought and an optimized integrated solution is required. For use in aircraft a high reliability of the the cooling system is required.

Under this task it should be looked at how these required cooling systems can be realized and a projection into future applications (technology forecast) should be provided. This technology forecast should be based on information provided by component suppliers, but this information is also to be checked on the basis of physical models and with dedicated laboratory tests as required. The forecast consists of a projection of incremental improvements (for example in material properties) and on step changes (changes in component basic principles and architectures). This should be performed for a product with an Entry into service (EIS) 2035.

Also, the integration with existing and foreseen aircraft systems should be looked at. It should be investigated how the integration with existing systems could provide additional overall benefits.

Task-4: Preliminary Design of Heat Exchanger System

Under this task the preliminary design of heat exchanger systems for Hybrid Electric Propulsion systems is to be performed.

It is expected that for a Hybrid Electric Propulsion system there are different temperature levels and heat flows compared to existing aircraft heat management systems. Examples for existing systems are the cabin air environmental control system (ECS) and galley cooling systems.

It should be looked at how these required heat exchangers can be realized and a projection into future applications (technology forecast) should be provided. Also, the integration with existing and foreseen aircraft systems should be looked at. It should be investigated how the integration with existing systems could provide additional overall benefits.

Task-5: Impact of Partial Discharge on Design

‘Partial discharge’ is a technical challenge specific to the design of high voltage electric systems on board of aircraft. As the electrical system is operated at higher altitudes, there is less resistance to partial discharge as the atmospheric pressure drops. As for novel electric propulsion systems operating voltages are foreseen to be higher than in existing applications to improve the specific weight of the system, this problem is even more impacting the overall design. The ‘Partial Discharge’ could become a limiting factor for the system.

Under this task the phenomenon of ‘Partial Discharge’ is to be researched and models are to be derived to support the other tasks in this topic in their design activities for specific electric components. This is to be based on theoretical studies as well as on laboratory tests to check the assumptions.

Also, it has to be discussed with industrial partners how far the topic is impacting health and safety issues and the certification of future aircraft.

Task-6: Optimization of Overall Electrical System

Under this task an overall system perspective for a Hybrid Electric Propulsion system is to be derived, for a

product with an entry into service (EIS) 2035.

This should integrate the research performed for the individual components and for Partial Discharge as specified in the previous tasks (T1-T6). The intention is to identify on top of component-wise improvements the benefits from the suitable integration of individual components.

As for the other tasks, the requirements for the overall optimization will be provided by industrial partners. It is expected to cover a suitable range of product applications in several studies.

A modelling and simulation approach is to be proposed, so that partial optimizations or trades can be performed. The modelling approach should integrate modelizations performed in the other tasks. The results are to be compatible with industrial tools for in use higher lever modelization, so that the results can be re-used in these tools.

The final optimization is expected to be extended beyond the final hardware demonstration, to take into account the results from these tests.

Due to the integrating scope of this task, it is envisaged that this task is performed by a partner with a lead role in the consortium.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
D-1	First version of target-setting tool for electric machines	Doc/SW	T0+24
D-2	Final version of target-setting tool for electric machines	Doc/SW	T0+48
D-3	Tool for the estimation of Power Electronic components, first version	Doc/SW	T0+24
D-4	Tool for the estimation of Power Electronics, final version	Doc/SW	T0+54
D-5	Electric components cooling system technology forecast, component designs and simulation software, preliminary version	Doc/SW	T0+24
D-6	Electric components cooling system technology forecast, component designs and simulation software, final version	Doc/SW	T0+48
D-7	Heat Exchanger (for Hybrid Electric Propulsion), preliminary design	Doc	T0+24
D-8	Heat Exchanger (for Hybrid Electric Propulsion) final design	Doc	T0+48
D-9	Partial Discharge, first laboratory assessment and simulation tool	Doc/SW	T0+27
D-10	Partial Discharge, final laboratory assessment and simulation tool	Doc/HW	T0+48
D-11	Preliminary overall electric design and integrated simulation	Doc	T0+36
D-12	Optimized overall electric design and integrated simulation based on hardware demonstration	Doc	T0+60

Milestones (when appropriate)			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
M-1.6-4	[Contribution to] Power bench pre-tested	Doc	T0+36
M-1.6-5	[Contribution to] Power bench fully tested	Doc	T0+42
M-1.6-6	[Contribution to] Architecture converged	Doc	T0+48

4. Special skills, Capabilities, Certification expected from the Applicant(s)

The ideal partner is expected to have a proven track record of participation in research programmes with industrial participation. The partner will have demonstrable capabilities within the aerospace sector and will have access either directly or through their supply chain to address all the areas required as part of this call.

It is imperative that a successful partner demonstrates his willingness and ability to meet evolving requirements set by the industrial partners due to the dynamic nature of the project.

- Experience in the preliminary design (technology forecast, modellization, experimental assessment and design studies) for electric components and architectures for aerospace applications:
 - Electric machines
 - Power electronics
 - Cooling systems for electric machines
 - Cooling systems for power electronics
 - Heat exchangers
 - Overall electric architecture
- Experience in aerospace specific design requirements, such as component safety and reliability and the operation at higher altitudes
- Experience in higher voltage electric applications
- It is desirable that partners have access to subscale rigs and demonstrators to support the programme.

IX. Landing gear large die-forged fitting with improved mechanical performance

Type of action (RIA or IA)	IA		
Programme Area	LPA Platform 2		
Joint Technical Programme (JTP) Ref.	WP 2.3.1.1		
Indicative Funding Topic Value (in k€)	400 k€		
Duration of the action (in Months)	24 months	Indicative Start Date⁹	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-LPA-02-07	Landing gear large die-forged fitting with improved mechanical performance
Short description (3 lines)	
This study aims at developing a new generation of Lower Center Fuselage, with a Body Landing Gear, in order to reduce the drag and the overall weight. The objective of this study is to develop a landing gear fitting with high mechanical properties, thanks to new generation alloys. Forged blanks geometry will be close to the final shape, in order to reduce weight, distortions and impact on the environment.	

⁹ The start date corresponds to actual start date with all legal documents in place.

1. Background

In the frame of Large Passenger Aircraft program, the current call for proposal is linked to WP 2.3 “Next Generation Lower Center Fuselage” and belongs to the WP 2.3.1 “High performance LCF components”, with the objective to propose Design to Cost proposals (Figure 7).

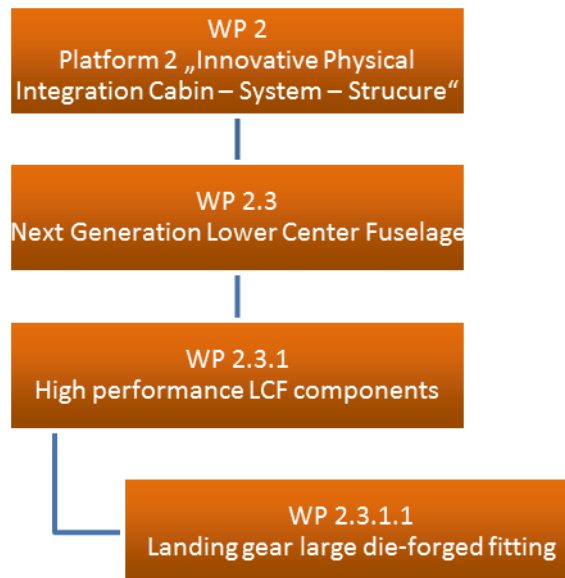


Figure 7

On most of the aircrafts, the Landing Gears are attached to the wings, and situated below them. On Single Aisle & Long Range families, the Wing MLGB is composed of metallic parts, whereas for the next generation long range aircrafts, this MLGB contains composite parts (Carbon Fibre Reinforced Plastic for the pressure bulkhead).

In order to offer more flexibility to the improvement of the wings, it is proposed to remove the landing gear from the wing and to attach it to the fuselage thanks to landing gear fitting. Next generation Lower Center Fuselage WP2.3 is based on the Body Landing Gear scenario. The current item is an enabler to reinforce the positive gain of this scenario.

2. Scope of work

Landing gear fittings will be made from die-forged parts. In order to enable the manufacturing of heavy and complex die-forged parts, the supplier often adds overthicknesses to increase the forging angles. This will lead to a large quantity of material removal during the machining, and then to non-negligible distortions.

The objective of this study is to get from the applicant the guarantee that such large fitting can be die-forged, with high mechanical properties and with a blank close to the final part shape. The objective would be to get better mechanical properties after the thermal treatment and also reduce the distortions after machining.

To do so, an innovative manufacturing route must be proposed to reduce the gap between the final part and the blank at its lowest value, with a reduction of the recurring cost of the overall manufacturing of such part.

The applicant must propose a high performance aeronautical material: 7xxx series alloy, al-li alloy or titanium alloy are good potential candidates. The objective is to check the balance between the mechanical properties and the manufacturability. Such fitting will be submitted to both static and fatigue loads and the applicant must demonstrate that this part can sustain such type of loading in the same way than standard die-forged fitting parts.

The design of the fitting is not frozen yet, but the dimensions of the overall envelop of the final part will be around 1m50 * 1m50 * 1m thick, around 150 kg each (Figure 8).

The final part will contain large pockets, which can reduce locally the thickness to less than 1cm.

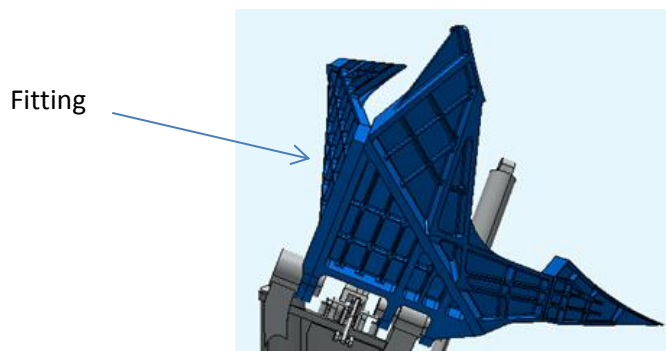


Figure 8

Recurring Costs reductions and Weight expected savings would be around 5%.

Several activities will be conducted for this project.

- Manufacturing of different thicknesses coupons in order to be representative of the fitting
- Mechanical test to characterize the material (if new alloy, not qualified yet, or different thickness than qualified range)
- Machining from coupons to check the distortions for several conditions

The maturity level to reach at the end of those 2 years activity is TRL3 which means the following:

- Analytical and experimental critical function and/or characteristic proof of concept must be demonstrated
- At least one feasible solution must be identified and relevant evaluations against the reference must be provided

Tasks		
<i>Ref. No.</i>	<i>Title – Description</i>	<i>Due Date</i>
T 1	Management and coordination	M0
T 2	Detailed planning for Engineering and Manufacturing activities with risks associated	M0 + 3M
T 3	Manufacturing of coupons with several thicknesses	M0 + 12M
T 4	Machining of specimens	M0 + 13M
T 5	Mechanical test to characterize the material for several thickness (if alloy not qualified yet)	M0 + 20M
T 6	Machining of final parts from the coupons	M0 + 20M
T 7	Definition of the shape of the die-forged part (blank)	M0 +24M
T8	Value and Risk analysis	M0 +24M

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
<i>Ref. No.</i>	<i>Title – Description</i>	<i>Type</i>	<i>Due Date</i>
D 1	Detailed planning for Engineering and Manufacturing activities with risks associated	Report	M0 + 3M
D 2	TRL2 maturity	Report	M0 + 12M
D 3	Mechanical behaviour Statement, comparison between conventional alloy and al-li, comparison with the aeronautical standard	Report	M0 + 24M
D 4	Machining Statement, distortions, analyses on encountered difficulties, comparison between conventional alloy and al-li, comparison with the data base	Report	M0 + 24M
D 5	TRL3 maturity Performance, Engineering, Manufacturing, Operability, Value and Risk)	Report	M0 + 24M

Milestones (when appropriate)			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
M 1	Forging feasibility	Technology review	M0 + 12M
M 2	TRL 2	Technology review	M0 + 12M
M 3	Mechanical behaviour (testing & machining)	Technology review	M0 + 24M
M 4	TRL 3	Technology review	M0 + 24M

4. Special skills, Capabilities, Certification expected from the Applicant(s)

Mandatory skills:

- Knowledge of aeronautical environment
- Recognized skills in forging large aluminium parts
- Recognized experience in forging al-li coupons
- Recognized experience in manufacturing parts for aeronautic
- Experience with numerical simulation to identify the shape of the blank as close as possible to the final part shape
- Availability of experience staff (numerical simulation, manufacturing route)
- Recognized skills in Materials and Processes

Mandatory capability:

- High capacity Press to forge large part
- High capacity Press to conduct cold compression
- Software to conduct the numerical simulation of the forging and thermal treatment (to identify the residual stresses)

X. High production rate composite Keel Beam feasibility

Type of action (RIA or IA)	IA		
Programme Area	LPA Platform 2		
Joint Technical Programme (JTP) Ref.	WP 2.3.1.2		
Indicative Funding Topic Value (in k€)	400 k€		
Duration of the action (in Months)	24 months	Indicative Start Date ¹⁰	Q2/2016

Identification	Title
JTI-CS2-2015-CFP02-LPA-02-08	High production rate composite Keel Beam feasibility
Short description (3 lines)	
The keel beam is a highly loaded structural element located in the lower centre fuselage. The aim of this call for partner is to conduct a feasibility study to propose a compromise between performance and cost taking into account manufacturing needs and constraints (low cost & high volume technology), through the use of a composite technology.	

¹⁰ The start date corresponds to actual start date with all legal documents in place.

1. Background

In the frame of Large Passenger Aircraft program, the current call for proposal is linked to WP 2.3 “Next Generation Lower Centre Fuselage” and belongs to the WP 2.3.1 “High performance LCF components”, with the objective to propose Design to Cost proposals (Figure 7).

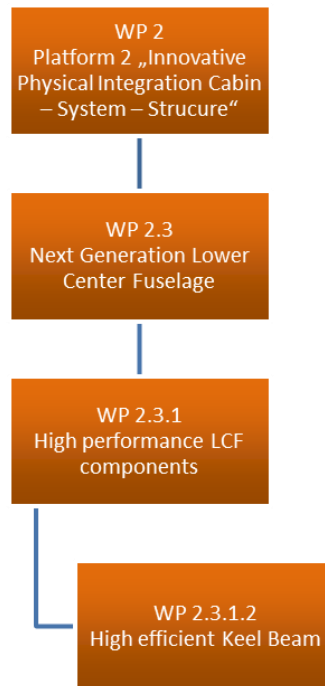


Figure 9

The Lower Center Fuselage is composed of several Work Packages, or Components. This Call For Partner is for the High-Efficient Keel Beam (WP 2.3.1.2). This will deal with airframe engineering and manufacturing domains.

Within the context of Work Package 2.3, the main technical innovation is based on the development of Body Landing Gear. Next generation Lower Center Fuselage WP2.3 is indeed based on the Body Landing Gear scenario. The current item is an enabler to reinforce the positive gain of the Body Landing Gear scenario.

Composite materials are preferentially used for unidirectional loaded parts for which the compromise between performance and weight is way more interesting than the metal. The Keel Beam is a highly loaded component in compression, along the fuselage direction. Therefore the composite surely offers some substantial benefits (due to density and lay-up optimization regarding the load path) over metal in terms of weight, reason why it is used for the new generation long range aircrafts. The objective of this study is to propose a composite scenario for such part with a manufacturing process enabling a production rate over 50 aircrafts a month with recurring costs comparable to metallic proposal.

2. Scope of work

This project proposes to develop new applications for composite materials for thick parts with a high production rate. The innovative proposal will lead to the reduction of operating costs (weight reductions and lighter maintenance program) together with low manufacturing costs (around 10% recurring costs reduction).

The part studied during this project is the Keel Beam (Figure 10): major component of the lower part of the centre fuselage, mainly loaded in compression along the fuselage direction.



Figure 10

Concept Phase:

The applicant will be responsible of the selection of innovative composite material and process. An innovative solution must be proposed, with the objective to sustain high mechanical loading at the lowest weight, in order to reduce the fuel burn. The deliverable will be a final report presenting the design and stress reports to justify the detailed design and process proposed, together with a Value and Risk presentation.

Manufacturing Phase:

The manufacturing route is also essential for this project. The applicant must indeed demonstrate that the process used to manufacture this part is robust and can be applied to high production rate programs (over 50 aircrafts per month) with a Design to Cost philosophy.

Detailed data:

This project applies to the Single Aisle aircraft family. On such aircrafts the length of the Keel Beam is around 6 meters (Figure 11), with a cross-section envelop around 500*250 mm². This component is a metallic beam made of four panels, connected together with bolted joints.

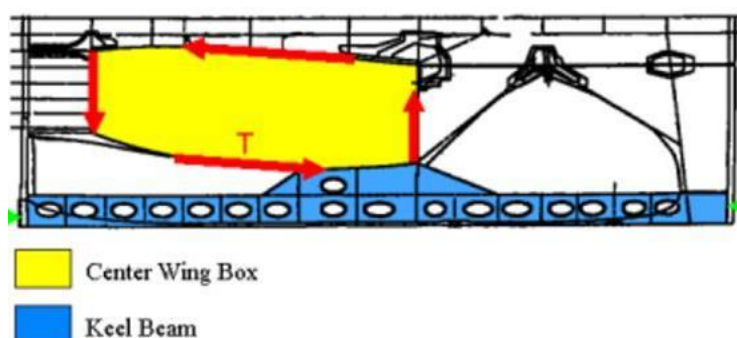


Figure 11

Under the fuselage bending effects, the Keel Beam is highly loaded in compression and must sustain a load of 200 tons.

This component is connected to the rest of the aircraft in 3 locations:

- Connected to rear fuselage at the rear pressure bulkhead
- Connected to forward fuselage at the front pressure bulkhead
- At the center wing box lower cover

The innovative Keel Beam solution developed by the partner must take into account these 3 interfaces.

The maturity level to reach at the end of those 2 years activity is TRL3 which means the following:

- Analytical and experimental critical function and/or characteristic proof of concept must be demonstrated
- At least one feasible solution must be identified and relevant evaluations against the reference must be provided

Tasks		
Ref. No.	Title – Description	Due Date
T 1	Management and coordination	M0
T 2	Detailed planning for Engineering and Manufacturing activities with risks associated	M0 + 3M
T 3	Development of a Master Design	M0 + 8M
T 4	Development of a Specific Design	M0 + 20M
T 5	Development of the Manufacturing route	M0 + 24M
T 6	Value and Risk analysis	M0 + 24M

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type	Due Date

D 1	Detailed planning for Engineering and Manufacturing activities with risks associated	Report	M0 + 3M
D 2	Master Design Coarse design, from sketches to first CAT Parts	Report, CAT Parts	M0 + 10M
D 3	TRL2 maturity	Report	M0 + 12M
D 4	Detailed Design Detailed CAT Parts, Stress reports	Report, CAT Parts	M0 + 20M
D 5	Manufacturing route	Report	M0 + 24M
D 6	TRL3 maturity	Report	M0 + 24M

Milestones (when appropriate)			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
M 1	TRL 2	Technology review	M0 + 12M
M 2	TRL 3	Technology review	M0 + 24M

4. Special skills, Capabilities, Certification expected from the Applicant(s)

Mandatory skills:

- Knowledge of aeronautical environment
- Recognized skills in Design
- Recognized skills in Static Stress
- Recognized experience in development of Aircraft parts
- Recognized knowledge and experience in Manufacturing of composite parts

Mandatory capability

- CAD Software : CATIA
- Numerical simulation Software

XI. Integrated main landing gear bay

Type of action (RIA or IA)	IA		
Programme Area	LPA Platform 2		
Joint Technical Programme (JTP) Ref.	WP 2.3.1.3		
Indicative Funding Topic Value (in k€)	600 k€		
Duration of the action (in Months)	24 months	Indicative Start Date¹¹	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-LPA-02-09	Integrated main landing gear bay
Short description (3 lines)	
This study aims at developing a new generation of Lower Center Fuselage, with a Body Landing Gear. This topic relates to the design of a main landing gear bay for a landing gear attached to the fuselage. The most promising solution has to be found disregarding the load compatibility, the best material utilization through a quantitative assessment, taking into account manufacturing requirement (recurring cost, high production rate, process stability...) at high level of integration for design to cost.	

¹¹ The start date corresponds to actual start date with all legal documents in place.

1. Background

In the frame of Large Passenger Aircraft program, the current call for proposal is linked to WP 2.3 “Next Generation Lower Center Fuselage” and belongs to the WP 2.3.1 “High performance LCF components”, with the objective to propose Design to Cost proposals (Figure 7).

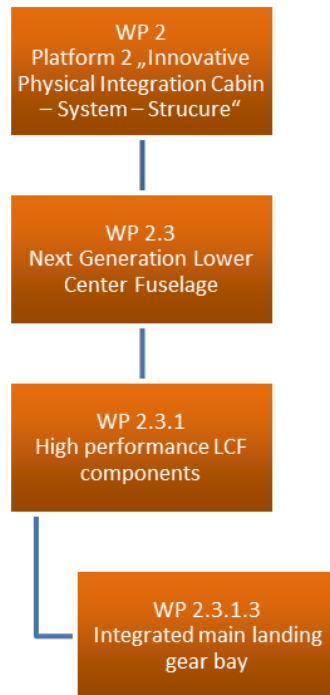


Figure 12

The LCF is composed of several Work Packages, or Components (Figure 13). This Call For Partner is for the Main Landing Gear Bay Work Package (MLGB WP 2.3.1.3). This will deal with engineering and manufacturing domains.

Within the context of Work Package 2.3, the main technical innovation is based on the development of Body Landing Gear. Next generation Lower Center Fuselage WP2.3 is indeed based on the Body Landing Gear scenario. The current item is an enabler to reinforce the positive gain of the Body Landing Gear scenario.

On most of the aircrafts, the Landing Gears are attached to the wings, and situated below them. On Single Aisle & Long Range families, the Wing Main Landing Gear Bay (MLGB) is composed of metallic parts, whereas for the new generation of Long Range aircrafts, this MLGB contains composite parts (Carbon Fibre Reinforced Plastic for the pressure bulkhead).

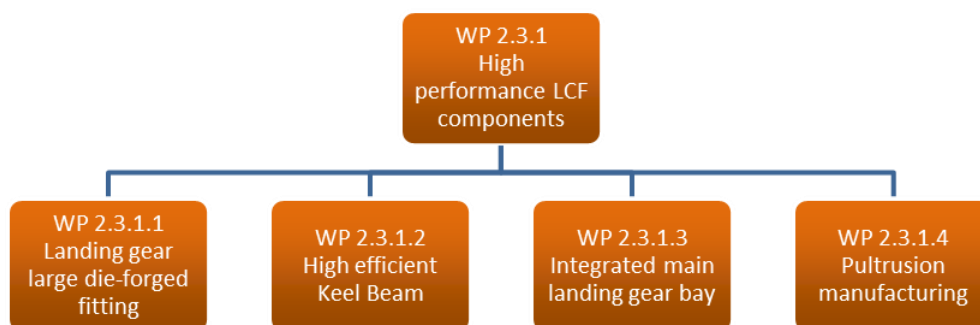


Figure 13

2. Scope of work

The objective of this project is to develop an innovative Main Landing Gear Bay compliant with a Body Landing Gear. The main characteristics of such proposal are the following:

- high load transfer
- high area of integration
- high production rate
- low production cost (reduction of Recurring Cost)

The applicant must propose and demonstrate robust concepts and technologies to sustain such high load: any concept, which complies with the external environment (from a global point of view: design, stress, etc.), can be proposed. The MLGB WP consists of 2 main areas (Figure 14):

- Horizontal pressurized floor
- Rear pressurized bulkhead

The major components of the MLGB WP are the gantries (metallic longitudinal beams along fuselage axis), the cross beams (perpendicular to gantries), the lateral frames, the pressure horizontal roof and the vertical rear pressure bulkhead. All these parts (or sub-assemblies) are linked to structure environment through structure interfaces (interface with Centre Wing Box, with Keel Beam, with Landing Gear Fittings, with Upper shell and with Cabin). Those interfaces will be presented in details to the partner.

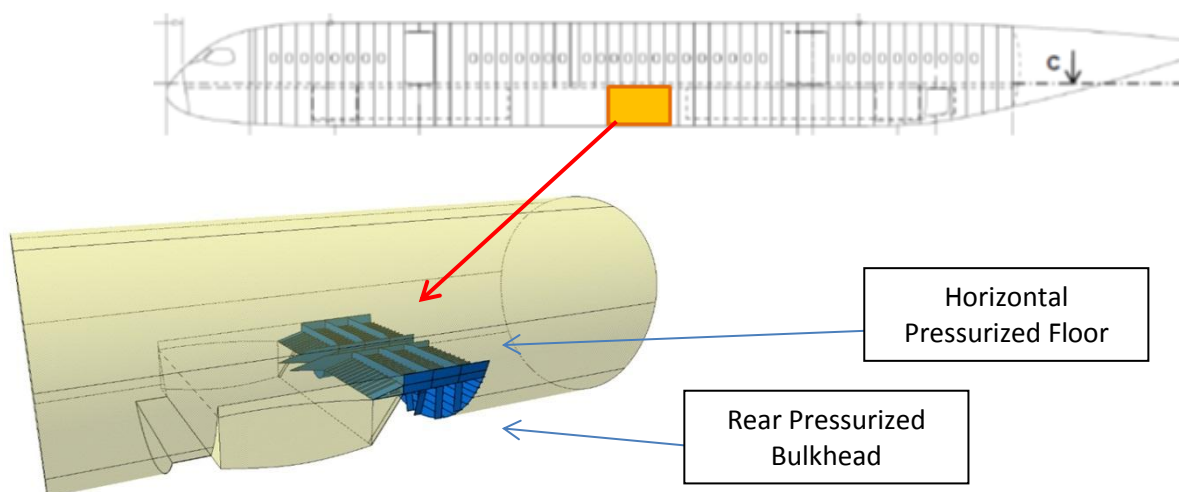


Figure 14

The applicant must demonstrate that this process is robust and can be applied to high production rate programs (over 50 aircrafts per month). Main phases are:

- Concept phase: selection of material, technology, local Design Principles, etc.
- Specific phase : design principles, space allocation mock-up based on a pre-sizing study
- Manufacturing phase : develop the manufacturing route

The applicant must demonstrate that the proposed scenario leads to a decrease of the recurring cost (expected benefits to target are 10%), with at least iso-performance than the state of the art MLGB technology.

The deliverable will be a final report presenting the design together with the manufacturing route.

Additional items to better understand the scope

- The global size : length = ~2500 mm / width = ~4000mm/ height = ~1200mm
- The static pressure to be sustained is around 1 bar.
- The local load introduction on the horizontal pressurized floor are around 100 tons on each side
- The demonstrator is for an equivalent Single Aisle aircraft

The maturity level to reach at the end of those 2 years activity is TRL3 which means the following:

- Analytical and experimental critical function and/or characteristic proof of concept must be demonstrated
- At least one feasible solution must be identified and relevant evaluations against the reference must be provided

All the previous phases are detailed into tasks in the following table:

Tasks		
Ref. No.	Title - Description	Due Date
Task 1	Propose a detailed planning for Engineering and Manufacturing (with all detailed tasks) <i>In order to understand deeply the need, technical exchanges with Airbus team will be necessary. Then a re-write of the need through a detailed planning will have to be done.</i>	M0 + 3M
Task 2	Define a baseline and trade off studies <i>From selected MLGB architecture (TRL3 inputs) define trade-off for technologies, materials, design principles, etc... All the trade-off will have to be described (technical description, costs, maturity and risks)</i>	M0 + 6M
Task 3	Perform the Specific Design (design and stress) with three maturity steps - Define Design Principles and Space Allocation Mock Up - Make static loop and update GFEM	M0 + 20M
Task 4	Define a Manufacturing route	M0 + 24M
Task 5	Value and Risk analysis	M0 + 24M
Task 6	Regular technical status meeting (monthly)	Every month
Task 7	Design & Planning Review Meeting at the end of each key milestone (end of maturity, end of phase, etc.) <i>Propose a meeting or accept a meeting requested by Airbus</i>	

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables

Ref. No.	Title - Description	Type	Due Date
Deliverable 1	Detailed planning for Engineering and Manufacturing activities with risks associated		M0 + 3M
Deliverable 2	Baseline and trade studies (material, technology, local design principle) – TRL2		M0 + 6M
Deliverable 3	MLGB Design technical data with maturity		M0 + 20M
Deliverable 3.1	Design principles and Space Allocation Mock Up cording to maturity level	CATIA v5 file	M0 + 20M
Deliverable 3.2	Pre-sizing study Reserve Factors mapping and updated MLGB GFEM	Report, mapping file	M0 + 20M
Deliverable 4	Manufacturing route (elementary parts, assembly)	Report	M0 + 24M
Deliverable 5	Jig and tools definition (and production line)	Report	M0 + 24M
Deliverable 6	TRL3 maturity	Report	M0 + 24M

Milestones (when appropriate)			
Ref. No.	Title - Description	Type	Due Date
M 1	TRL 2	Technology review	M0 + 6M
M 2	TRL 3	Technology review	M0 + 24M

4. Special skills, Capabilities, Certification expected from the Applicant(s)

The project will need the following skills and capabilities:

- Skill 1: design composite and metallic (leader, expert and designer)
- Skill 2: stress composite and metallic (leader, expert and designer)
- Skill 3: airframe architecture
- Skill 4: project management
- Skill 5: Manufacturing Engineering for elementary parts (composite and metallic)
- Skill 6: Manufacturing Engineering for assembly
- Skill 7: Quality for Elementary parts (composite and metallic)
- Skill 8: Quality for Assembly

- Capability 1: CAD software
- Capability 2: Stress tool
- Capability 3: jigs and tools to produce composite parts (size link to MLGB WP part)
- Capability 4: jigs and tools to produce metallic parts (aluminium and titanium)
- Capability 5: jigs and tools to assemble parts

XII. Development of pultrusion manufacturing applications

Type of action (RIA or IA)	IA		
Programme Area	Large Passenger Aircraft		
Joint Technical Programme (JTP) Ref.	WP 2.3.1.4		
Indicative Funding Topic Value (in k€)	600 k€		
Duration of the action (in Months)	24 months	Indicative Start Date ¹²	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-LPA-02-10	Development of pultrusion manufacturing applications
Short description (3 lines)	
Pultrusion is a rapid and continuous out of autoclave process used to simultaneously extrude and polymerize profiles. Thus, this process offers high energy savings perspectives. The objective of this study is to develop the technology to increase the number of applications.	

¹² The start date corresponds to actual start date with all legal documents in place.

1. Background

In the frame of Large Passenger Aircraft program, the current call for proposal is linked to WP 2.3 “Next Generation Lower Center Fuselage” and belongs to the WP 2.3.1 “High performance LCF components”, with the objective to propose Design to Cost proposals (Figure 7).

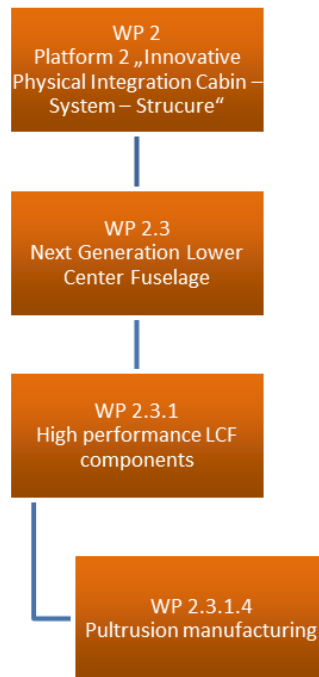


Figure 15

Polymerisation of most of the aeronautical composites requires autoclave. This latter is a high energy & time consumer.

Pultrusion is an innovative alternative to extrude composite parts without the need of autoclave (polymerisation is done during the extrusion). This project aims at increasing the quantity of extruded sections that can be produced thanks to this process, in an aeronautical environment.

2. Scope of work

The objective of this study is to develop new potential applications for pultrusion manufacturing. The applicant must demonstrate good extrudability (low distortion, final shape corresponding to the design) together with relevant mechanical properties (polymerisation with no defect, static requirements, Fire Smoke & Toxicity requirement).

The applicant must demonstrate that this process is robust and can be applied to high production rate programs (over 50 aircrafts per month).

The targetted applications are today made of Pre-impregnated materials, with Epoxy resin, associated to multi-axial stacking sequence (typically using 0° / 45° / -45° / 90°). The applicant must demonstrate the use of aeronautic fibers : “Intermediate Modulus” or “High Resistance”.

The indicative thickness range is from 1mm to 6mm. The maximum envelop of the cross-section of the parts is 200m*200m. Figure 16 presents an exemple of extruded sections to be manufactured by pultrusion. This list is non exhaustive and will be detailed during the first meetings.

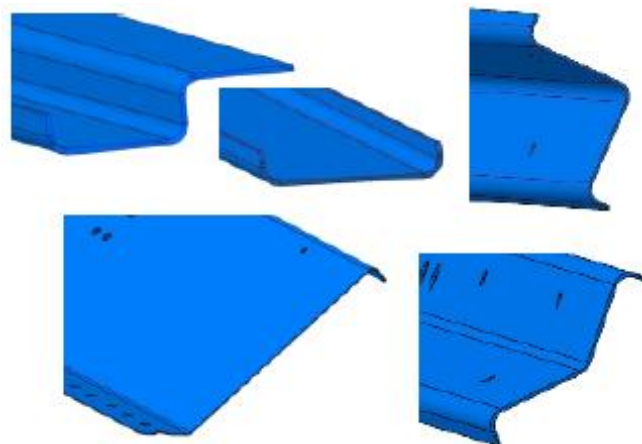


Figure 16

An experimental campaign must be conducted in order to check the mechanical behaviour of the pultruded material. During this campaign, the following tests will be conducted : Tension Modulus, Compression Modulus, Bearing, Strength after impact, FST-flame, FST-toxicity, FST-fire. It must be demonstrated that such product can be controlled by standard Non-Destructive Inspection.

Tasks		
<i>Ref. No.</i>	<i>Title – Description</i>	<i>Due Date</i>
T 1	Management and coordination	M0
T 2	Detailed planning for Engineering and Manufacturing activities with risks associated	M0 + 3M
T 3	Manufacturing of two different profiles (thicknesses & sections) Mechanical strength evaluation	M0 + 12M
T 4	TRL2 maturity	M0 + 12M
T 5	Manufacturing of representative part extruded section	M0 + 20M
T 6	Mechanical characterization Mechanical tests of main aeronautical criteria (modulus, FST, Non-destructive Testing)	M0 + 24M
T 7	TRL3 maturity	M0 + 24M

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
D 1	Detailed planning for Engineering and Manufacturing activities with risks associated	Report	M0 + 3M
D 2	Two first extruded sections First extruded sections	Report, parts	M0 + 12M
D 3	TRL2 maturity report	Report	M0 + 12M
D 3	Representative extruded sections Standard and new extruded sections that can be manufactured by pultrusion, list of today's process limitations	Report, parts	M0 + 20M
D 4	Mechanical behaviour Results and analysis of the experimental campaign	Report	M0 + 24M
D 5	TRL3 maturity report	Report	M0 + 24M

Milestones (when appropriate)			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
M 1	TRL 2	Technology review	M0 + 12M
M 2	TRL 3	Technology review	M0 + 24M

4. Special skills, Capabilities, Certification expected from the Applicant(s)

Mandatory skills :

- Recognized skills in pultrusion
- Recognized experience in carbon fibers
- Engineering skills (composite material, mechanical behaviour)

Mandatory capability :

- Pultrusion dies
- Non-Destructive Testing capacity
- Hability to perform standard coupons CFRP test
- Capacity to produce around 300 Tons of Carbon parts per year

XIII. Touchscreen control panel for critical system management functions

Type of action (RIA or IA)	IA		
Programme Area	LPA Platform 3		
Joint Technical Programme (JTP) Ref.	WP3.1.3.3 "Tactile HMI"		
Indicative Funding Topic Value (in k€)	2000 k€		
Duration of the action (in Months)	93 months	Indicative Start Date ¹³	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-LPA-03-04	Touchscreen control panel for critical system management functions
Short description (3 lines)	
The purpose of this Call for Partner is to develop a touchscreen control panel that could replace standard overhead control panels as an incremental step on existing aircrafts and more globally on future cockpits. In order to address all overhead functions, the technology should be compliant with failure conditions up to CAT. Therefore, the whole control chain shall be secured from the touch sensor to the controlled system. The project should last 3 years at most and target TRL5 maturity by the end of the project thanks to a representative prototype that would be integrated on a large aircraft cockpit simulator. An extension may be decided to feed Airbus Disruptive Cockpit Demonstrator.	

¹³ The start date corresponds to actual start date with all legal documents in place.



1. Background

Current cockpit overhead control panels have not evolved for several years. On recent programs, part of the communication links toward A/C systems has been transferred to digital busses but most critical links remain as discrete signals. Regarding the human-to-machine interface, control panels are still based on electromechanical switches whose reliability is limited. In this context, touchscreen technology can be seen as an opportunity to propose a new concept of overhead panels. It could provide more flexibility to embed evolutions over A/C life, improved reliability and innovative HMI for pilots. However, to take full profit of the concept, all overhead controls, including the most critical ones, should be embeddable in the touchscreen control panels.

The framework of this Call for Partner is the LPA IADP - Platform 3, Technology Stream "Enhanced Flight Operations and Functions (WP3.1), in particular, those functions and solutions for man-machine efficiency. One of the major goals of this work package is to explore and use the potential of new available technologies such as touchscreen and its integration in commercial aircraft. Concretely this call for partner is part of work package WP 3.1.3.3 "Tactile HMI".

2. Scope of work

The objective of this Call for Partner is to define relevant requirements and to develop a touchscreen control panel system that can provide the capacity to host critical commands towards A/C systems (engine, FUEL, ...). The activities of this Call will cover the design, development and tests of the equipment itself, the associated system architecture as well as the operational concept, in order to reach TRL5 maturity by the end of the project.

The integration and tests activities will consist in a first phase, leading to prototype testing on Airbus enhanced cockpit simulator, and a second conditional phase for integration and testing on the Disruptive Cockpit demonstrator.

The expected contribution from the applicant consists in:

- a) Supporting the requirements definition at equipment and system level based upon requirements provided by the aircraft manufacturer
- b) Defining touchscreen control panel units based upon system architecture concept provided by the A/C manufacturer
- c) Building & testing prototypes (hardware and software) for concept validation, operational and performance verification on applicant facilities, interfacing with A/C systems models to be provided by the A/C manufacturer
- d) Support Airbus during the integration, tests and validation of the prototypes on Airbus simulators and/or flight tests platform

Tasks		
Ref. No.	Title - Description	Due Date
Task 1	Detailed project plan – A detailed project plan, including WBS, scope & schedule shall be established.	04-2016 to 08-2016
Task 2	Definition of requirements - Requirements shall be defined at A/C, System and equipment level to support the scenario of A/C system management over a complete flight from power up to power down. The requirements shall cover touchscreen technology, ergonomics, operational use, architecture, safety and environment.	07-2016 to 01-2017
Task 3	Validation & verification plan - For each requirement a proposed means of compliance shall be defined for the validation & verification process.	01-2017 to 04-2017
Task 4	System definition – System and components concept shall be defined to support the defined requirements a) State of the art and review of available technologies. b) Definition of potential solutions for: • Control panels units • System architecture • Operational use	10-2016 to 04-2017

Tasks		
Ref. No.	Title - Description	Due Date
Task 5	System validation – The various building blocks of the system shall be evaluated and validated individually per analysis and/or tests: a) Building of prototype and associated test rig for concept validation. b) Validation test and analysis. c) Trade-off and selection of the most appropriate solutions	01-2017 to 10-2017
Task 6	System verification – The final product shall be refined and verified: a) Building of prototypes, system and associated test rig for verification. b) Verification test and analysis of the selected solution. c) Support to Airbus during the integration, tests and validation of the prototypes on Airbus simulator and/or flight tests platform The expected maturity level for the final prototype is TRL5.	10-2017 to 01-2019
Task 7	Conditional System integration in the Disruptive Cockpit demonstrator: Review of Disruptive Cockpit demonstrator requirements, prototype tests results and conditional integration and tests of updated prototype a) Update of prototypes and associated system b) Support to Airbus during the integration, and tests on Disruptive Cockpit Demonstrator	01-2020 to 10-2023
Task 8	Final Report – All results shall be formalized in the final report.	10-2023 to 12-2023

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type	Due Date
D1	Project plan - A detailed project plan, including WBS, scope & schedule.	Document	09-2016
D2	System Requirement Document – Compilation of relevant requirements.	Document	01-2017
D3	Validation & Verification Plan – Definition of the validation & verification process.	Document	04-2017
D4	System Definition Document – Description of the potential concepts.	Document	04-2017
D5	Validation prototypes for most critical building blocks (TRL4)	Prototype	07-2017
D6	Full scope verification prototype (TRL5)	Prototype	07-2018
D7	System Validation & verification Report – Compilation of evidences from the validation & verification process.	Document	09-2018
D8	Final Report (for enhanced cockpit)	Document	06-2019
D9	Update of Requirements and Description documents - For disruptive cockpit adaptation	Document	12-2020
D10	Disruptive Cockpit demonstrator prototype (TRL5)	Prototype	12-2020
D11	Integration report	Document	12-2021
D12	Final report (for disruptive cockpit)	Document	12-2023

Milestones			
Ref. No.	Title - Description	Type	Due Date
M1	Preliminary Design Review Review of the system High Level Requirements, solutions to be evaluated and main building blocks to be prototyped.	PDR	Before task 5
M2	Design Review Review of the trade-offs, definition of the system architecture to be tested.	DR	Before task 6
M3	Test Readiness Review (enhanced cockpit) Review of the prototypes to be tested and test procedures.	TRR	Middle Task 6
M4	Decision Gate for Disruptive Cockpit integration	DG	Before Task 7
M5	Test Readiness Review (Disruptive cockpit) Review of the prototypes to be tested and test procedures.	TRR	Task 7 start + 1 year

PDR: Preliminary Design Review - DR: Design Review - TRR: Technical Readiness Review - DG: Decision Gate



4. Special skills, Capabilities, Certification expected from the Applicant(s)

Following skills and capabilities are expected from the Applicant:

- a) Long experience and high skills in the design and manufacture of cockpit display systems for the aerospace industry.
- b) Long experience in the design of touchscreen technology for civil or military aircraft environments, including touchscreens for critical system control functions.
- c) Knowledge and experience of various touchscreen technologies used on aircrafts
- d) Capacities to develop both hardware and software including Graphical User interfaces
- e) Working prototypes (even at low maturity level) demonstrated of one or several building blocks of the targeted system

XIV. New flight crew oxygen mask concept for prolonged use in civil aircraft

Type of action (RIA or IA)	IA		
Programme Area	LPA Platform 3		
Joint Technical Programme (JTP) Ref.	WP3.1.3 Functions and solutions for man machine efficiency		
Indicative Funding Topic Value (in k€)	550 k€		
Duration of the action (in Months)	93 months (end 2023)	Indicative Start Date ¹⁴	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-LPA-03-05	New flight crew oxygen mask concept for prolonged use in civil aircraft
Short description (3 lines)	
Current flight crew oxygen masks are not adapted to prolonged use as required for some aircraft operations. The objective of the project is to develop and validate mask solutions which would drastically increase the mask comfort for long duration while maintaining safety of the crew.	

¹⁴ The start date corresponds to actual start date with all legal documents in place.



1. Background

Current flight crew oxygen masks have been designed for short emergency situations and are not adapted to prolonged use, either in emergency situation (e.g. long depressurized diversion above FL100) or preventive daily wear (e.g. as specified by FAR 121.333).

In addition, the future cockpit will feature new Man Machine interaction means, potentially incompatible with state of the art oxygen masks.

The objective of the project is to define relevant requirements and to develop mask solutions which would drastically increase the mask comfort for long duration use and compatibility with innovative man machine interface.

This element is then an enabler within the disruptive cockpit concept demonstrator developed in the frame of LPA pLatform 3.

2. Scope of work

The project will cover the development and tests of the equipment itself, its compatibility with other worn devices, the associated oxygen system architecture as well as training and operation acceptability assessment under consideration of social & cultural aspects.

A first phase will lead to integration tests on large passenger aircraft enhanced cockpit demonstrator, and a conditional second phase will allow testing on a disruptive cockpit demonstrator.

The targeted maturity at completion will be TRL5.

The project will include the following activities, combining both the design and prototyping of the mask and the all the related human factors aspects :

- e) Support definition of requirements at equipment and system level
- f) Define mask concepts
- g) Build & test prototypes for concept validation, performance verification & certification compliance
- h) Support definition of requirements
- i) Evaluate human factors aspects of new mask concepts / prototypes
- j) Test and evaluate physiological performance of new mask concepts / prototypes

The A/C manufacturer will provide requirements at aircraft, system and equipment levels, as well as the system architecture to support new mask concept.

The validation of the concept and prototype will be performed on A/C manufacturer cockpit mock-up or flying aircraft platform.

The activities will take place within the Work package 3.1.3 “Functions and solutions for Man Machine Efficiency”, and will be split into the following 10 tasks:

Tasks		
Ref. No.	Title - Description	Due Date
Task 1	Detailed project plan – A detailed project plan, including WBS, scope & schedule shall be established.	05-2016
Task 2	Definition of requirements - Requirements shall be defined at System and equipment level based upon A/C manufacturer inputs, to support the scenario of a prolonged use of oxygen by the cockpit crew	09-2016
Task 3	Validation & verification plan - For each requirement a proposed means of compliance shall be defined for the validation & verification process.	12-2016
Task 4	Concept definition – New concepts shall be defined to support the defined requirements: c) Review of available mask technologies within and outside the aerospace industry. d) Definition of potential concepts including mask and A/C system.	03-2017

Tasks		
Ref. No.	Title - Description	Due Date
Task 5	Concept validation – The potential concepts shall be evaluated and validated per analysis and tests: d) Building of prototype, system and associated test rig for concept validation. e) Validation test and analysis of new concepts. f) Selection of the most promising solution.	09-2017
Task 6	Concept verification – The most promising solution shall be refined and verified: d) Building of prototype, system and associated test rig for verification. e) Verification test and analysis of selected solution.	03-2018
Task 7	Standardization concept – Based on the performed study, the outline of a new mask standard shall be defined as input for standardization bodies.	06-2018
Task 8	Final Report for first phase – All results shall be formalized in the final report.	09-2018
Task 9	Conditional System integration in the Disruptive Cockpit demonstrator: Review of Disruptive Cockpit demonstrator requirements, prototype tests results and conditional integration and tests of updated prototype c) Update of prototypes and associated system d) Support to Airbus during the integration, and tests on Disruptive Cockpit Demonstrator	06-2019 to 10-2023
Task 10	Final Report for second phase – All results shall be formalized in the final report.	10-2023 to 12-2023

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type	Due Date
D1	Project plan - A detailed project plan, including WBS, scope & schedule.	R	05-2016
D2	System Requirement Document – Compilation of relevant requirement.	R	09-2016
D3	Validation & Verification Plan – Definition of the validation & verification process.	R	12-2016
D4	System Definition Document – Description of the potential concepts.	R	03-2017
D5	System Validation & verification Report – Compilation of evidences from the validation & verification process.	R	03-2018
D6	Oxygen mask prototype with associated system	Prototype	03-2018
D7	Standardization Document – Outline of a new mask standard.	R	06-2018
D8	Final Report (Enhanced cockpit)	R	09-2018
D9	Update of Requirements and Description documents- For disruptive cockpit adaptation	Document	12-2019
D10	Disruptive Cockpit demonstrator prototype (TRL5)	Prototype	12-2020
D11	Integration report	Document	12-2021
D12	Final report (for disruptive cockpit)	Document	12-2023

*Type: R: Report - RM: Review Meeting - D: Delivery of hardware/software - M: Milestone

Milestones (when appropriate)			
Ref. No.	Title - Description	Type	Due Date
M1	Requirement Review	RM	10-2016
M2	Concept Review	RM	04-2017
M3	Critical Design Review	RM	09-2017
M4	Prototype Acceptance review	RM	03-2018
M5	Final review (Enhanced cockpit)	RM	08-2018
M6	Decision Gate for Disruptive Cockpit integration	DG	09-2019
M7	Test Readiness Review (Disruptive cockpit) Review of the prototypes to be tested and test procedures.	TRR	12-2020

4. Special skills, Capabilities, Certification expected from the Applicant(s)

- a. Long experience and high skills in the design and manufacture of pilot oxygen masks for the aerospace industry.
- b. Long experience in the consideration of human factors and physiological aspects in the design of oxygen masks.
- c. Long experience in the design and certification of aerospace oxygen systems.
- d. Capability to test oxygen systems and masks for compliance demonstration of aviation regulation.
- e. Recognized participation to relevant standardization bodies

- f. Long experience and high skills in human factors analysis.
- g. Long experience and high skills in aerospace medicine, in particular regarding oxygen protection.
- h. Capability to test and evaluate physiological performance of oxygen systems.

XV. Head Up System integration in next generation cockpits

Type of action (RIA or IA)	IA		
Programme Area	LPA Platform 3		
Joint Technical Programme (JTP) Ref.	WP 3.1, 3.3 and 3.4		
Indicative Funding Topic Value (in k€)	1000 k€		
Duration of the action (in Months)	36 Months	Indicative Start Date¹⁵	Q2 2016

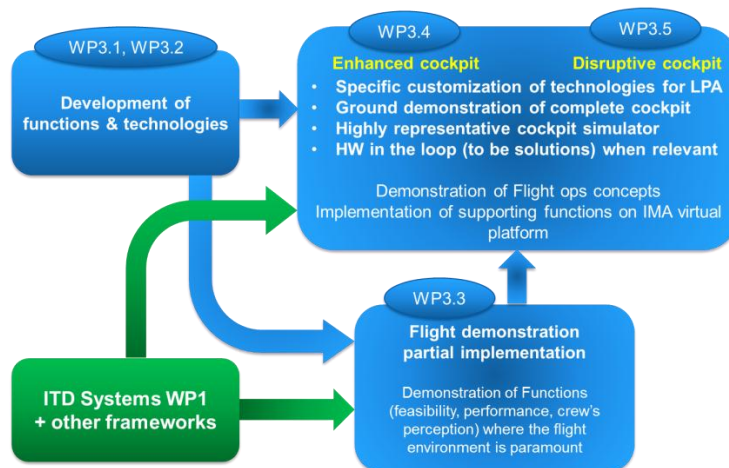
Identification	Title
JTI-CS2-2015-CFPW2-LPA-PF3-03	Head Up System integration in next generation cockpits
Short description (3 lines)	
The Head Up Display is now becoming more and more a standard equipment in aircraft, both for economical reasons (the cost has been reduced drastically) and because the demonstration of its benefits is now widely shared. This opens the possibility of new usages in next cockpit generation, or in the evolution of existing ones. The objective of the project is to analyze how the capacities of the Head Up Display could be used to provide new functionalities, in combination with other visualization means, and to demonstrate them on a fixed simulator. The bidder will be expected to contribute to the analysis of potential new functionalities, to prototype them in an existing Head Up System, to provide the airframer with two test equipment, including rapid prototyping capacities, and to participate to, and support, bench tests at the Airframer facilities.	

¹⁵ The start date corresponds to actual start date with all legal documents in place.

1. Background

This CfP Partnership is to be hosted within the LPA Platform 3 “Next Generation Aircraft Systems, Cockpit and Avionics”, in which one of the objectives is the development of next generation cockpits for bizjets. The ambition of the platform is to introduce incremental but significant innovations in terms of navigation, sensors and Man Machine Interface (MMI), and in terms of cockpit concepts. Enabling technologies are numerous, one of them is Head Up Displays, which are now becoming a standard in bizjet cockpits and so can become an integral and very valuable part of new cockpit concepts. HUDs are key enablers to many innovative low visibility operations, including so-called “Equivalent Visual Operations” which are essential for operations at secondary airports.

Within LPA/PF3 a number of new functions are developed and integrated in WP 3.1 addressing the approach phase, in particular innovative guidance modes and assistants with extensive utilisation of GNSS upgrades. Also in WP 3.1 new Man Machine Interfaces based on touch screens are integrated in reference cockpit designs. Cockpit concepts integrating the new technologies with existing ones, in a manner which in itself must be innovative, are elaborated and demonstrated in WP 3.1, 3.3 and 3.4.



The studies in LPA PF3 will typically start at TRL 3 to 4 with the analysis of the intended functions and elaboration of operational and MMI concepts, continue with integration and simulations based on evolution of cockpit demonstrators, and lead to ground and/or flight tests.



Cockpit EASy II Falcon F7X



For next generation cockpits, one of the objectives is to analyse how Head Up Displays and Systems can be fully integrated as baseline in next generation cockpit concepts in order to maximize the efficiency of the new technologies mentioned above, among others, and to maximize the performances of the cockpit in general.

The future Partner (CfP) is expected to support the Airframer in that objective, starting with concept studies, capture of requirements, development of demonstrators and testing.

The innovation brought directly by this topic will be the exploration and demonstration of innovative ways to use HUDs in cockpits; it will also be a key enabler of new cockpit concepts integrating the Clean Sky 2 technologies.

2. Scope of work

The partner will be expected:

- to contribute to the analysis of potential new functionalities
- to provide two representative HUD systems, at least for the combiner and the projector. The HUD will have to integrate a state of the art Combined Vision System capacity. Horizontal Field of View of at least 40°, and vertical Field of View of at least 30° are required. Also in order to be representative of typical bizjet architectures and dynamic operations, an autonomous capacity of the HUD system to update all the symbology, including the synthetic vision, at 50 Hz or more is required, and must be independant from the main avionics. Expected resolution of the HUD is 1280*1024 or more.
- to support the HUD system integration on a bizjet cockpit simulator located at the Airframer's premises.
- to provide rapid prototyping of the intended new MMIs, as required by the integration objectives, and associated logics in the HUD system
- to support, and contribute to, the evaluations performed by the airframer on the simulator
- to contribute to the identification of required architecture changes for the integration of the next generation HUD system regarding the global design objectives and safety requirements, including a vision of the compatibility with certification rules.

The project is decomposed into three main activities:

- Integration of two physical HUD systems on bizjet cockpit simulator
- HUD MMI & functional change analysis, as required by integration objectives, including concept, prototyping and evaluation
- Head Up Display and System integration architecture change analysis for next generation concept

The following table gives the main tasks to be carried by the CfP for each activity.

Tasks		
Ref. No.	Title - Description	Due Date
HUD Bench integration	T1.1 Identify from requirements (see §3) and apply HUD system design change for simulator integration	T0+2 -> T0+4
	T1.2 HUD Integration on Airframe manufacturer simulator	T0+6 -> T0+10
	T1.3 Results Assessment	T0+9 -> T0+10
Functionalities & MMI validation	T2.1 Prototype the new functionalities and MMI changes as specified by the airframer (see §3)	T0+6 -> T0+32
	T2.2 Support the evaluations at the Airframer's premises and remotely	T0+10 -> T0+34
	T2.3 Results Assessment	T0+34-> T0+36
Head Up System Architecture	T3.1 Contribute to identify the boundaries between HUD system, sensors, avionics and Flight Guidance system	T0 -> T0+6
	T3.2 Identify next generation HUD integration architecture design change (including I/O)	T0+6 -> T0+34
	T3.3 Results Assessment	T0+34 -> T0+36
T4.0	Project final assessment	T0+36

They can be schematized in the following timeline:

		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
1 - HUD Integration in the Airframer's bench													
	1.1 - Identify from requirements (see §3) and apply HUD system design change for simulator integration												
	1.2 - HUD Integration on Airframe manufacturer simulator												
	1.3 - Results Assessment												
2 - Validation of functionalities and MMIs													
	2.1 - Prototype the new functionalities and MMI changes as specified by Dassault-Aviation (see §3)												
	2.1.1 - Rapid prototyping - Initial version (V0)												
	2.1.2 - Updated version (V1)												
	2.1.3 - Updated version (V2)												
	2.1.4 - Final Version												
	2.2 - Support the evaluations at the Airframer's premises												
	2.2.1 - V0												
	2.2.2 - V1												
	2.2.3 - V2												
	2.2.4 - Final Version												
	2.3 - Results Assessment												
3 - Architecture of Head Up System													
	3.1 - Contribute to identify the boundaries between HUD system, sensors, avionics and Flight Guidance system												
	3.2 - Identify next generation HUD integration architecture design change (including I/O)												
	3.3 - Results Assessment												
4 - Project final assesment													

Note: tasks 2.2.x will require the physical presence of representative(s) of the selected partner at the airframer's premises on a part time basis, not exceeding 6 weeks cumulated, and full time remote support.

3. Major deliverables/ Milestones and schedule (estimate)

In order to perform the tasks, the airframer will provide to the partner the following inputs :

- HUD system installation requirements for integration on Airframer's simulator
- Functions and MMI specifications for rapid prototyping on Airframer simulator. Several versions of this document will be provided integrating in steps the results from WP3.1
- Architecture requirements for next generation HUD system. Several versions of this document may be provided.

The partner will be expected to provide the deliverables summarized in the table below.

Deliverables				
Ref. No.		Title - Description	Type	Due Date
HUD Bench integration	D 1.1	HUD system design change to support HUD integration on DA simulator	Report	T0+4
	D 1.2	Two HUD system (including two combiners, two projectors and a rapid prototyping environment that supplies the two projectors)	Equipment	T0+6
	D 1.3	HUD Integration test Report	Report	T0+10
Functionalities & MMI validation	D 2.1	Rapid prototyping V0 – initial version	Software	T0+10
	D 2.2	Rapid prototyping V1 – updated version	Software	T0+16
	D 2.3	Rapid prototyping V2 – updated version	Software	T0+24
	D 2.4	Rapid prototyping VF – final version	Software	T0+32
HUD System Architecture	D 3.1	Next generation HUD design change – initial version	Report	T0+18
	D 3.3	Next generation HUD design change – final version	Report	T0+34
D4.0		Project final assessment document	Report	T0+36

Milestones (when appropriate)			
Ref. No.	Title - Description	Type	Due Date
M1.1	HUD system integration on simulator completed		T0+10
M2.1	First rapid prototyping completed & available on the simulator for evaluation		T0+10
M2.2	Final rapid prototyping completed & available on the simulator for evaluation		T0+32
M3.1	First architecture for next generation HUD system		T0+18
M3.2	Final architecture for next generation HUD system		T0+34

4. Special skills, Capabilities, Certification expected from the Applicant(s)

The applicants should have:

- an extensive experience in HUD system design, manufacturing and testing,
- demonstrated experience in civil certification (CS Part 25),
- experience in state of the art HUD functionalities such as combined vision system.

In order to support quick turn modifications, the applicant should have the capability to perform rapid prototyping and parametrization of parameters in the HUD system installed on the Airframer's simulator.

1.2. Clean Sky 2 – Regional Aircraft IADP

I. Smart-grid converter

Type of action (RIA or IA)	RIA		
Programme Area	REG		
Joint Technical Programme (JTP) Ref.	WP 2.3.4.2 – Advanced Electrical Power Distribution System with Enhanced Electrical Energy Management		
Indicative Funding Topic Value (in k€)	800 k€		
Duration of the action (in Months)	36 months	Indicative Start Date¹⁶	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-REG-01-01	Smart-grid converter
Short description (3 lines)	
Development and prototype manufacturing of innovative high/low voltage DC/DC "resonant cellular" converter with automatic inversion for innovative "smart-grid" based electrical network.	

¹⁶ The start date corresponds to actual start date with all legal documents in place.



■ **Background**

The main objective of this topic is to design and develop an innovative strategy for an highly decentralized, modular and flexible smart grid based advanced Electrical Power Distribution System (EPDS) network.

In addition, the EPDS will be equipped with the Enhanced Electrical Energy Management (E^2 -EM) functionalities in order to further reduce or even delete the overload capabilities of main generators and thus saving weight for electrical machines integration. With respect to Clean-Sky1 E-EM, the E^2 -EM will also introduce utilization of local ultra/super-capacitors as energy buffers during high and rapid transitory energy requests from some critical loads (e.g., EMAs).

The above will allow to perform on ground demonstrations of the key elements of innovative EPDS in order to demonstrate that relevant solutions correctly perform in a relevant Regional A/C operative environment, i.e. the Regional A/C electrical ground demonstrator of Clean-Sky2 (named "Iron Bird").

▪ Scope of work

The EPDS for Regional A/C will include a “smart grid” concept conversion network with innovative algorithms for automatic inversion and resonant cellular approach. Consider the following electrical network, i.e. the one used in Clean-Sky1 as the future Regional AEA EPGDS architecture (Fig. 1).

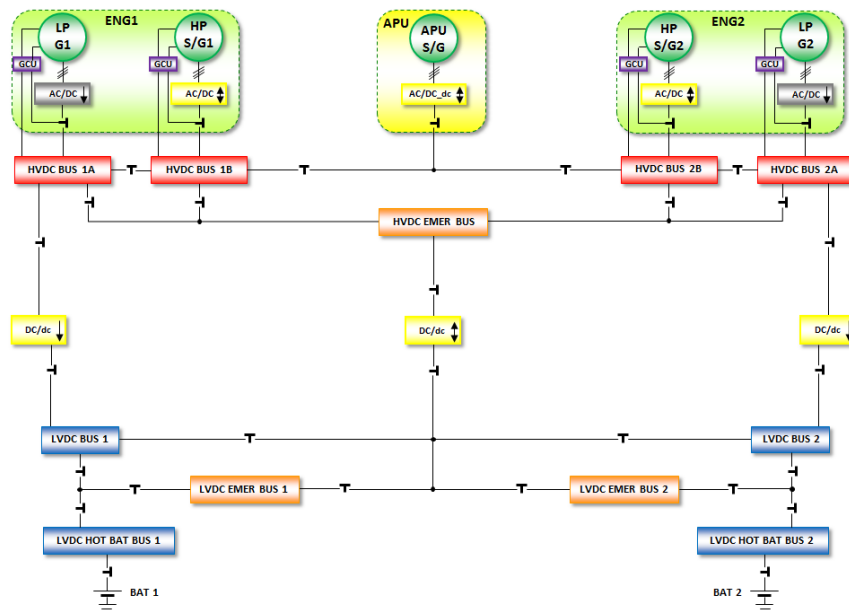
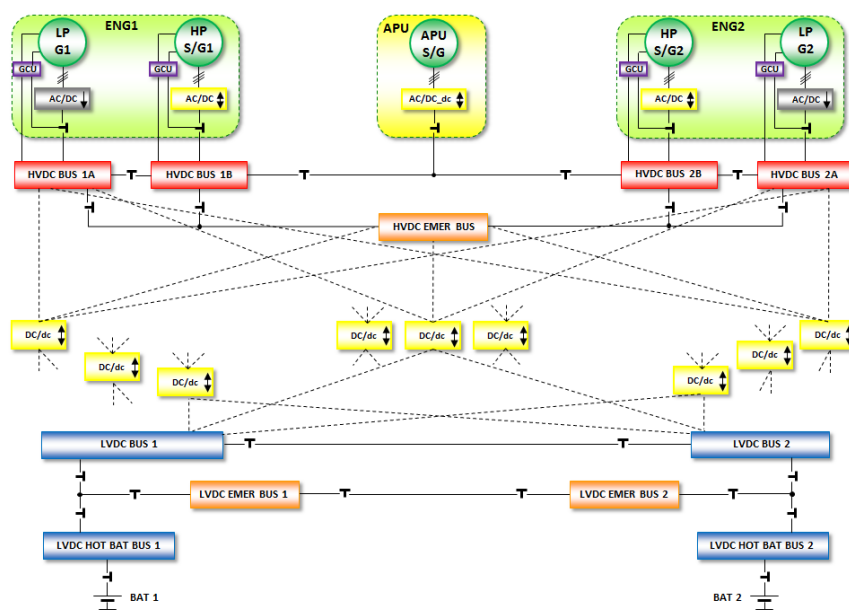


Fig. 1: HVDC/LVDC conversion network with monolithic, hard switching DC/DC converters

In this architecture, the bidirectional DC/DC converters are “conventionally” monolithic, hard-switching and used in buck or boost modes without chance of intelligently change their operation modes on-fly.

Instead, the smart grid network for Clean-Sky2 activities will consist of a set of cells, each constituted by a resonant converter (DC/DC bi-way converter), so that only a fraction of the nominal rated power weights on each converter drive. The entire system is then equipped with a “supervisor” controller which, by using artificial intelligence and sensor fusion techniques, will have the task of optimally managing the distribution of power between the various cells, as well as to deal with the selection of the operating mode (buck or boost mode) for the individual cells of the converter modules. A potential (but only indicative) network based on the above concept is reported in Fig. 2.



The effective smart grid architecture, in terms of number of converters, HVDC and LVDC busses, and interconnection possibilities, will be defined with respect to the final chosen Iron Bird architecture.

Objective

The set of cells shall be able to perform step-down (buck) and step-up (boost) conversion, relying on a topological structure for “soft switching” modulation (e.g., zero voltage switching or zero current switching), moreover being suitable for possible on-fly mode inversion.

Moreover, the system shall be suitable to perform advanced energy management functions by automatically reverse the operating mode, from buck to boost mode, and viceversa, as reaction to energy management

objectives persecution.

Requirements

General Requirements

Given the above scenario, the selected Candidate shall develop a set (at least four) of resonant cellular DC/DC bidirectional converters, able to be supervised by a devoted “supervisor” equipment, in order to implement a local “smart grid” behaviour and specific “energy management” strategies.

The overall system (converters + supervisor) shall be fully interfaced with the Iron Bird test rig, and the energy management mode (i.e. automatic inversion of the modes) shall be activated or deactivated in case of need depending on the specific test configuration. When activated in energy management mode, the supervisor shall take autonomous full control of the converters. All the documentation required for allowing the correct electrical, mechanical and control interfaces with the electrical test rig will be provided to the selected Candidate as an input at the early stage of the Project.

The converters “smart grid” behavior, possibly embed as a supervision logic into an external device (supervisor), is required for obtaining an optimal sharing and allocation of the electrical energy among the different voltage busses.

The cells shall be on-fly arranged in order to substitute the normal monolithic converters, specifically in order to react to failure events of the converters (or of the voltage busses), hence allowing for a dynamic grouping of the single cells into logically equivalent complete converters. Power allocation to the different active cells shall be defined by the supervisor, consequently to the evaluation of different variables and parameters, available as measurements to the supervisor. In Fig. 3, as illustrative example only, the possibility to obtain a complete converter by substituting the functionalities of two faulty cells with still active converters is reported.

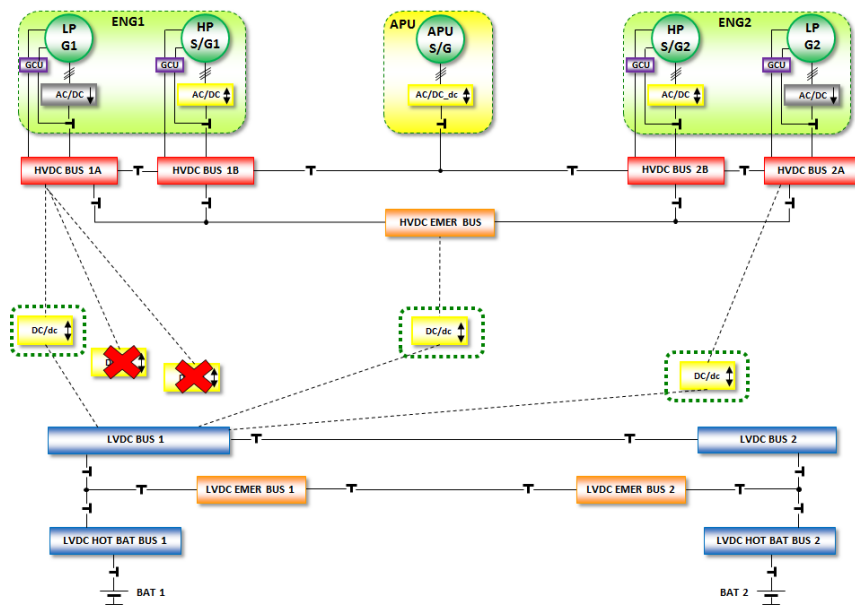


Fig. 3: “Smart grid” expected behavior

The “energy management” logic to be implemented shall be able to control the behavior of the resonant

cellular converters, by selecting in each operating phase the conversion direction (buck or boost) for each cell. The selection shall be performed by analyzing a set of parameters able to give an indication about the most suitable power flow direction for each cell. Such parameters can include also simulated environmental factors, flight phases and priorities of the loads powered by the converters. The simultaneous presence of more conversion cells acting between more LV and HV busses constitutes a key factor to be considered by the energy management algorithm.

Given the complexity of the scenario, a strong formal and theoretical approach shall be proposed in order to properly define the structure of the energy management strategy. The formal approach proposed shall be able to justify its adequateness in terms of energy management algorithm robustness against dynamic variation of the operation conditions. Moreover, automatic or semi-automatic technique of translation of the formal structure into a firmware (microprocessor or FPGA) shall be proposed, in order to minimize the chance of programming error.

Innovative techniques for DC/DC converters regulation shall be proposed, in order to comply with requisites of rapid control set point variation, as required by the energy management strategy. Formal proof of robustness against uncertainties and industrial stability of such techniques shall also be evaluated.

- **Environmental Requirements**

The resonant cellular converters will be located in a laboratory room for functional tests. Therefore, the environmental requirements shall be limited to a compatibility of the equipment with the laboratory environmental conditions (detailed Interface Control Document will be provided).

- **Electrical Power Requirements**

The Iron Bird rig will provide DC power when supplied with 270 VDC input power, whose normal and abnormal characteristics in steady-state and transient are listed in MIL-STD-704F reference power quality standard.

The system shall include connectors and wires to connect the various inputs and outputs to/from the different voltage busses, according to the detailed electrical scheme contained with the ICD document to be provided to the selected Candidate. All the connections shall support the rated voltage as specified in MIL-STD-704F. All the connections shall be isolated from the ground and between them.

The detailed power ratings of the converter cells (< 10kW) will be provided to the Candidate at the early stage of the Project. However, they will be compliant with typical aeronautical power systems and loads.

- **Hardware Requirements**

The final equipment shall be composed by at least four DC/DC bidirectional converters, each one intended as a cell having the possibility to be dynamically connected between a specific HV bus and a specific LV bus among the ones available on the electrical network (at least two cells for each pair of HV and LV busses). The final configuration and correspondent number of cells will be provided to the Candidate, referring to the Iron Bird structure and particularly to the final number of HV and LV busses.

The electrical topology of the cells shall be selected in order to obtain a power density > 0.5 kW/kg.

The converters shall be designed in order to allow their coexistence on the electrical network with active generators. Moreover, the electrical elements (e.g. switches) shall be designed in order to increase reliability with respect to current solutions.

▪ **Operational Requirements**

The converters shall continue to work for an acceptable period in case of lack of cooling features.

FMEA or FMECA analyses shall be provided for failure analyses.

The system design shall avoid, as much as possible, scheduled maintenance.

The converter cells shall be able to communicate between them and with a central system for monitoring and control purposes, by means of appropriate protocols (e.g. CAN or ARINC).

The converter cells shall allow easy reprogramming, by specific ports (e.g. USB or RS232) accessible from a laptop.

▪ **Safety Requirements**

The converter shall comply with European and French standards related to electrical power installations, and low voltage electrical installations.

The converters shall embed safety and protections logics (e.g. overcurrents, overvoltages) in order to react to potential failures and communicating the faulty status to an external device.

▪ **Software Requirements**

During design phase, the equipment shall be modeled and tested in a simulation environment in order to pretest its functionalities and performances. SABER models shall be provided by the supplier, demonstrating the effectiveness of the proposed converter topology by means of accurate simulations. Also the equipment supervisory control and monitoring strategy effectiveness and performances shall be demonstrated by means of simulations, in SABER or other simulation tools (AMESim / Modelica Dymola). "Behavioral" and "functional" level models shall be implemented, for the equipment object of the Proposal, integrating them with provided Iron Bird equipment models.

The firmware for equipment control and monitoring shall be automatically or semi-automatically generated starting from the simulation models. Multi-platforms simulation approach shall be preferred. A preliminary testing phase for the firmware using simulation tools is required.

▪ **Other Criteria to meet**

The system shall be as compact as possible but it may be handle for maintenance and manual operations. The compactness of the proposed solutions will be a selection criteria for the CfP. It shall be designed to the minimum weight that assures all performances required. The converter shall be air-forced cooled by means of an internal fan, or alternatively liquid cooled, should the power switches require a more effective heat dissipation.

Tasks		
Ref. No.	Title - Description	Due Date
KOM	A Kick off meeting will be organized to review the technical requirements and the project logics and organization agreed with the partner during the negotiation phase.	T0
T 2.3.4.2-1	<u>Requirements analysis</u> The main objective of this task is to review the customer requirements, and describe the equipment to be designed, manufactured, qualified and provided to the customer for testing.	[T0 ; T0+ 3M]
T 2.3.4.2-2	<u>Converters modelling and simulation</u> The main objective of this task is to derive an accurate model of the resonant cellular converters and associated control (low level), suitable for smart grid and energy management scopes (both behavioural and functional level).	[T0 + 3M ; T0+ 9M]
T 2.3.4.2-3	<u>Preliminary Design</u> The main objective of this activity is to validate the equipment requirements and check that equipment preliminary design is consistent with these requirements: architecture concept according to performance and safety requirements, sizing, interfaces definition, substantiation of design choice.	[T0 + 3M ; T0+ 12M]
T 2.3.4.2-4	<u>Smart grid behaviour and energy management strategy definition</u> The main objective of this task is to analyse, design and theoretically proof the effectiveness of the smart grid and energy management strategy. Software and mathematic tools are required to be used in order to respectively prove the benefits and the formal properties of the designed smart grid and energy management strategy.	[T0 + 12M ; T0+ 16M]
T 2.3.4.2-5	<u>Firmware definition and testing</u> The main objective of this task is to define the smart grid and energy management strategy as a firmware for the computational core of the converters. Simulation based approaches shall be used for proving the firmware correctness in terms of energy management objectives achievement.	[T0 + 16M ; T0+ 21M]
T 2.3.4.2-6	<u>Critical Design</u> The main objective of this activity is to realize the detailed design (mechanical, electrical, thermal, ...), realize detailed cad drawings, finalize safety analysis, prior to launch equipment manufacturing.	[T0 + 12M ; T0+ 24M]
T 2.3.4.2-7	<u>Manufacturing</u> The main objective of this task is to realize the converter cells and associated equipment for smart grid and energy management purposes, following the CDR documentation.	[T0 + 24M ; T0+ 30M]
T 2.3.4.2-8	<u>Testing and validation</u> The main objective of this task is to perform the final tests for validating the resonant cellular converter actions in terms of smart grid and energy management objectives achievement.	[T0 + 30M ; T0+ 34M]

Tasks		
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Due Date</i>
T 2.3.4.2-8	<u>Optimization and support</u> The main objective of this task is to analyse the feedbacks coming from the customer and provide further support for optimization activities.	[T0 + 34M ; T0+ 36M]

▪ **Major deliverables / Milestones and schedule (estimate)**

Deliverables			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
D2.3.4.2-1	Analysis phase – Requirements matrix and support documentation	R	T0 + 3 months
D2.3.4.2-2	Converter topology and control – Simulation models of the converter structure and associated controls	R/P	T0 + 9 months
D2.3.4.2-3	PDR - Preliminary Design Review and associated deliverables	R	T0 + 12 months
D2.3.4.2-4	Energy management definition – Analysis of the results of the simulation models for energy management preliminary tests	R	T0 + 16 months
D2.3.4.2-5	Firmware specification – Implementation of a preliminary firmware for energy management purposes		T0 + 21 months
D2.3.4.2-6	CDR - Critical Design Review and associated deliverables	R	T0 + 24 months
D2.3.4.2-7	Installation and commissioning - Delivery of the complete system with its associated documentation (preliminary DDP), installation and commissioning on site	R/P	T0 + 30 months
D2.3.4.2-8	Validation final tests and DDP - Validation test report and final results (final DDP)	R	T0 + 34 months
D2.3.4.2-9	Optimization and support - The CfP Supplier shall support the rig operations to correct potential faults during this probation period	R/P	T0 + 36 months

Milestones			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
M2.3.4.2-1	Preliminary Design Review	R	T0 + 12 months
M2.3.4.2-2	Critical Design Review	R	T0 + 24 months

▪ **Special skills, Capabilities, Certification expected from the Applicant(s)**

The Candidate organization shall have:

- Documented expertise in electrical system design (power generation, power conversion, power distribution network, power consumer) for aeronautical, transport or high energy application,
- a well recognized experience in advanced control system techniques
- knowledge of Industrial/Aeronautical field constraints and procedures,
- experience in system simulation methods and modeling,
- good practice in English language.

The Candidate shall preferably rely on a background in control and supervision of complex systems. Experience in laboratory or industrial test benches design, manufacture and installation will be an asset.

▪ **Abbreviations**

A/C	Aircraft
AEA	All Electrical Aircraft
CDR	Critical Design Review
CfP	Call for Proposal
DC	Direct Current
DDP	Declaration of Design and Performance
E-EM	Electrical Energy Management
E ² -EM	Enhanced Electrical Energy Management
EMA	Electro-Mechanical Actuator
EPDS	Electrical Power Distribution System
EPGDS	Electrical Power Generation & Distribution System
FMEA	Failure Mode and Effect Analysis
FMECA	Failure Mode, Effects and Criticality Analysis
FPGA	Field Programmable Gate Array
HVDC	High Voltage Direct Current
IADP	Integrated Aircraft Development Platform
ICD	Interface Control Document
LVDC	Low Voltage Direct Current
PDR	Preliminary Design Review
VDC	Voltage Direct Current

II. Powered WT model design and manufacturing of the FTB2 aircraft configuration for aerodynamic tests in wind tunnel at low and high Reynolds number

Type of action (RIA or IA)	IA		
Programme Area	REG		
Joint Technical Programme (JTP) Ref.	WP3.5		
Indicative Funding Topic Value (in k€)	2500		
Duration of the action (in Months)	22	Indicative Start Date ¹⁷	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-REG-02-02	Powered WT model design and manufacturing of the FTB2 aircraft configuration for aerodynamic tests in wind tunnel at low and high Reynolds number
Short description (3 lines)	
Design and manufacturing of a low speed wind tunnel full aircraft model representing the FTB2 configuration with an indicative span of 3m (scale 1:8.6). The complete model will include the A/C model and the powered propulsive system and must be compatible for testing at two different wind tunnels, one atmospheric WT for configuration development tests and preliminary data gathering, and a pressurized WT for high quality data acquisition and Re effects investigation.	

¹⁷ The start date corresponds to actual start date with all legal documents in place.



1. Background

The activities under this CfP will support the development and assessment of new aerodynamic devices and concepts and the loads Control (LC) technologies for an innovative Regional Turboprop A/C concept that has been proposed by EADS-CASA targeting the Horizon 2020 objectives as described in the JTP document of Clean Sky 2 (CS2).

This innovative A/C concept is based on a set of new technologies that will be investigated and developed in CS2 (Clean Sky 2 program), many of which will be selected for their implementation and integration in the FTB2 Demonstrator according to a higher maturity level as described in the WP3.5 of the REG Platform of CS2 and, finally, tested in flight to show a TRL6.

The FTB2 Demonstrator is based in a AIRBUS Defense and Space S.A.U. (former EADS-CASA) C295 with fixed winglets recently installed and a FCS developed in the National FT4B project -declared as Additional Activity- that will be extended with new added functions to control the new wing control surfaces in CS2 (aileron, flap, spoiler and winglet) for the optimal A/C performances and aerodynamic efficiency at each flight phase, and for the loads control (Manoeuvre and Gust Loads Alleviation, MLA & GLA). Active controls will include pilot and sensors in the loop within safety levels to perform experimental flights in Regional FTB2 demonstrator.

The

Figure 17 below depicts the FTB2 Demonstrator and the different new technological concepts to be developed and tested in CS2, that include new technologies focused in the improvement of the aerodynamics performances in low or high speed, like the "Multi-Functional Flaps" (to be implemented in the outer flap) or the morphing leading edges and the "Adaptive Winglets" (to be implemented in the winglets) and other technologies whose aim is reducing the A/C weight, like new wing design based on composites (to be implemented in the outer wing) and the different concepts and functionalities for loads control like the new spoilers and aileron.

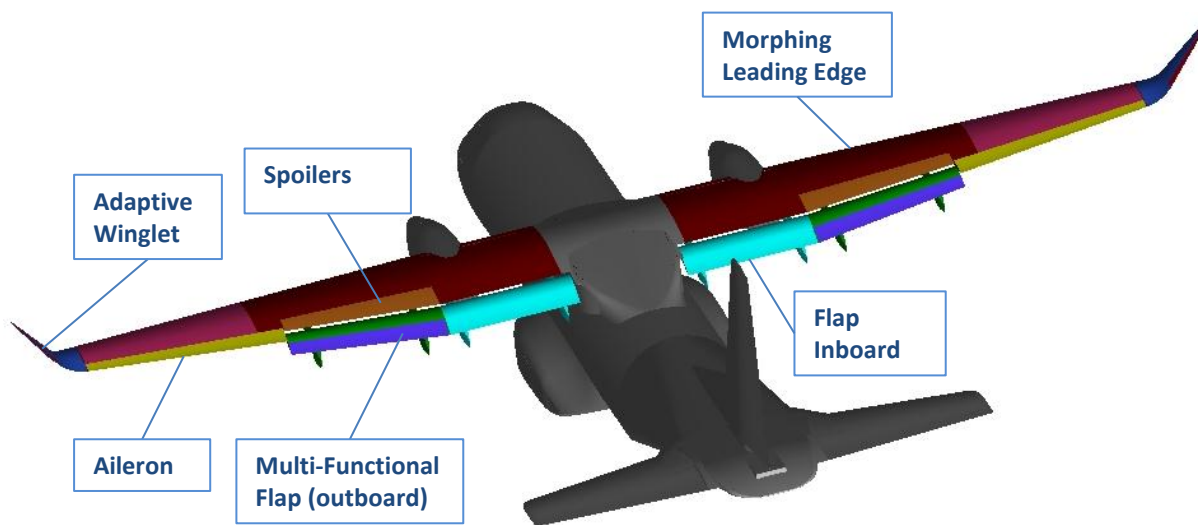


Figure 17: CS2 Air Vehicle Concepts within the framework of the FTB2

The propellers slipstream impacts a lot some relevant technology concepts for the FTB2 like the flaps, the morphing leading edge, the spoilers, and the overall loads control concepts. Thus, **the power simulation in this wind tunnel model (WTM) is of paramount relevance on this topic.**

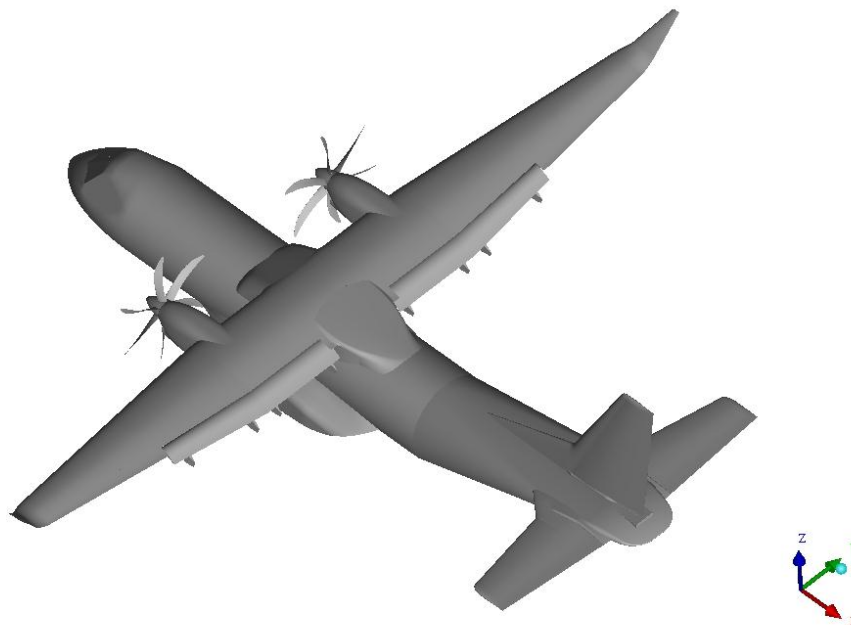


Figure 18: CS2 configuration with Power On (installed propellers) within the framework of the FTB2

Technological challenges

The WT Model to be designed and manufactured under this CfP plays a key role in the investigation of these new aerodynamic and load control concepts to be integrated in the FTB2 and therefore it has to provide the adequate capabilities for the development and assessment of them.

Furthermore the wind tunnel model must incorporate advanced technologies that contribute to the reduction of the test costs by increasing test efficiency while at the same time allowing for richer and higher-quality data.

A **remote control for the propeller blades** positioning would have relevant impact on costs and productivity of the test campaigns due to the large number of blade settings needed as the new concepts in FTB2 will be operated in a wide range of flying conditions and engine and propellers settings.

It's also welcome the implementation of new technologies applied to **telemetry** that will accommodate the commonality of the data transmission **at the two different wind tunnel** (atmospheric for configuration tests and pressurized for high quality gathering data) and will enable the interfaces and the adequate broadband for all the sensors and data measured of the complete wind tunnel model, including **the new control devices**, and specially of **the rotary balance** that will serve for the adequate correlations of the different wing effects and even the noise issues against the propeller unsteady loads.

The approach of using a common wind tunnel model imposes also additional challenges to its design and general arrangement for testing with the same supports at both WT, as well to the tolerances and deformations due to the high loads on the pressurized WT. These commonality requirements challenge also the propulsive system that must be able to implement and to provide high CT (thrust coefficient) at both WT facilities, one of them pressurized.

TECHNOLOGY CHALLENGE

Design and manufacturing of FTB#2 WTM for Dual use in WTT
(Mandatory)

WTM easy- adaptable to installations for tests time and cost reduction
(Mandatory)

Remote control and telemetry in reduced size installation
(Strongly Recommended)

High performance power system to test propeller installation at high Reynolds numbers
(Mandatory)

COMMENTS

A single model -approximate span of 3m (scale 1:8.6)- is required to be used in two different wind tunnel installations:

- Low Reynolds number installation: first tests for concept aerodynamic purposes during initial design phase.
- High Reynolds number installation: second tests for high fidelity data gathering in detailed aerodynamic design and flight clearance.
- Support structure
- Force Balances
- Energy installation for propeller power plant
- Propeller pitch –model reference spinner size: 73 mm-
- Flap settings of I/B and O/B –model reference O/B flap span 395 mm-
- Rotatory balances in power plant –model reference spinner size: 73 mm-

The power supply have to fullfill high requirements for rotating propellers at high rates representative at high Reynolds numbers tests. Changes related to:

- Reduced model size
- High rotating speed
- Propeller – wing installation

Note: Descriptions of the technologies proposed by the applicant devoted to every Technology Challenge described within the topic are wellcome.

2. Scope of work

The subject of this topic is the design and manufacturing of a wind tunnel full aircraft model representing the FTB2 configuration for wind tunnel test with an approximate span of 3m (scale 1:8.6).

The complete model will include the A/C model and the powered propulsive system and must be compatible for testing at two different wind tunnels, one atmospheric WT for configuration development tests and preliminary data gathering, and a pressurized WT for high quality data acquisition and Re effects investigation.

The activities include three main lines of work:

- 1) **The A/C model** has to be designed in a modular approach in order to accommodate the new devices under development by other partners for the FTB2, including the flaps, spoilers, aileron, active winglet and morphing wing leading edges. For each component, more than one manufactured set (named Design 1 and Design 2), as well as the reference component, have to be provided –mandatory-. For each set it is highly recommended that the settings of the control surfaces can be remotely controlled. It is envisaged that the model may include pressure taps but not local balances on the control surfaces.
- 2) **The propulsion simulation system** will include two sets of propellers (left & right) including spares, the complete power supply system (electrical, pneumatic, hydraulic) capable of simulating in pressurized conditions the full scale aircraft with 25.81m span, 3000SHP engines and 1200 rpm propellers; and the propeller instrumentation, namely rotary shaft balances and the associated data transmission and processing equipment. The propellers should be designed in such a way that a quick change of the propeller pitch is possible, but at a minimum needing neither to remove them from the model nor to manually set the angle. A strongly recommended technological proposal may be remote control propeller pitch which reduces test operational time and installation complexity, but other technological alternatives are accepted to back up the topic principal scope. The power supply can be common for both wind tunnel or different for each wind tunnel as long as the model can use both of them. It is obviously preferred that if possible an existing power supply system at the wind tunnel is used rather than developing and ad-hoc one.
- 3) **The integration in the two wind tunnels**, including model support, power supply, main balance (including balance crossing system), and instrumentation connections and data acquisition. The model support should be common for both wind tunnels at least in the area close to the model itself.

The scope of this topic is thus the complete process from model design to model integration in the wind tunnel and model commissioning for testing. The cost of the actual campaigns are out of the scope of this call and will be covered either by subcontracting or by call for tender.

■ **Work Packages and Tasks**

All the activities under this CfP are included in the WP3.5 of the CS2 REG Platform, specifically in the WP3.5.1 “FTB2 Wing”.

The proposed activities are described in the Table 1 below which shows also the deadline for each task. The estimated reference T0 is January 1st, 2016

A total of 5 work packages (WP) are considered.

WP1 is devoted to the design of the wind tunnel model based on the specification provided by EADS-CASA and is splitted into 2 task, one for the baseline model, that include the components of the legacy configuration, and another devoted to the new devices investigated in CS2.

WP2 is devoted to the manufacturing of the complete wind tunnel model (except the propulsive system) and is splitted into 2 task, one for the baseline model, that include the components of the legacy configuration, and another devoted to the new devices investigated in CS2.

WP3 deals with the propulsive simulator and will include complete propulsive system and comprises 4 tasks, one for the propellers design and manufacturing, other for the propellers pitch control system; and the last one for the power supply to drive the propellers in both facilities

WP4 is devoted to the integration of the model in the WT facilities.

Tasks		
Ref. No.	Title – Description	Due Date
Task 1.1	Baseline Wind Tunnel Model Design The design of the WTM of the complete a/c at the baseline geometry standard with the provisions for the power simulation system and model instrumentation.	<i>T0+5M</i>
Task 1.2	New Devices Design The design of WTM components of the new control devices developed in CS2 (winglet, flaps, spoiler, aileron, leading edge). Two sets of new control devices are expected representing the design solutions at two stages to be tested in WTT - Design 1 (initial controls design and concept) - Design 2 (final controls design)	<i>T0+7M</i> <i>T0+15M</i>
Task 2.1	Baseline Wind Tunnel Model Manufacturing The manufacturing of the WTM representing the A/C in the legacy configuration (pre-CS2 configuration) including the control devices.	<i>T0+7M</i>

Tasks		
Ref. No.	Title – Description	Due Date
Task 2.2	New Devices Manufacturing The manufacturing of the new control devices under investigation and development in CS2 for the FTB2 (flaps, active winglets, spoilers and ailerons). Two sets of new control devices are expected to be manufactured representing the respective two design solutions to be tested in WTT • Design 1 (initial controls design and concept) • Design 2 (final controls design)	T0+9M T0+17M
Task 3.1	Propulsive System (propellers) The design and manufacturing of two propellers (both rotating in the same direction) with blade spares.	T0+8M
Task 3.2	Propulsive System (Pitch control) The design and manufacturing of the system to control the propeller pitch.	T0+8M
Task 3.3	Propulsive System (Power Supply). The design, manufacture and integration of the most appropriate power supply and engines selected in Task 1.1 that drives the propellers rotation.	T0+8M
Task 3.4	Propulsive System (Instrumentation and data acquisition) 6 DOF Rotary Shaft Balances for the propellers	T0+8M
Task 4.1	Wind Tunnel Adaptation to Low-Reynolds WT The design and manufacturing of the model support, the integration with the main balance (including the power supply crossing system) and all other interfaces to the low Reynolds WT facility	T0+9M
Task 4.2	Wind Tunnel Adaptation to High-Reynolds WT The design and manufacturing of the model support, the integration with the main balance (including the power supply crossing system) and all other interfaces to the high Reynolds WT facility	T0+18M

Table 1: Tasks definition and description of activities.



▪ **Requirements and Specifications**

A document with detailed specifications will be provided by EADS-CASA. It will include maximum estimated aerodynamic loads on the model, the ranges of the incidence angles and controls deflections, the operating conditions of the propellers, the flaps settings, the model instrumentation, the manufacturing tolerances and any other relevant data.

▪ **Inputs and Outputs**

EADS-CASA will provide to the beneficiary the CAD model files of the full scale A/C. CATIA format or some other format (step or iges) will be used.

The outputs from the beneficiary are identified in the different deliverables. All items delivered will be accompanied of the adequate documentation for its operation in WTT.

▪ **Effort and costs**

It is claimed that the proposal would include a cost breakdown. In general, details about budget distribution are welcome.

▪ **The Applicant Mission and IPR's**

The mission of the applicant will be to take complete responsibility of the activities of this call and to be able to provide the complete WTM, as prescribed, ready for testing in the two WT facilities.

All the information and data to be exchanged between EADS-CASA and the Beneficiary of this CfP will be regulated under specific NDA and IPR regulations that will recognise mutually the their property following the recommendations and directives of the CS JU.

Further access to and use of the complete WTM and all the deliveries under this CfP by both parties (EADS-CASA as topic manager and the Beneficiary of this CfP) will be grandted regardless any specific regulation regarding the NDA and IPR.

3. Major deliverables/ Milestones and schedule (estimate)

The deliverables and milestones are in accordance with the general work plan of the Regional Aircraft FTB2 demonstrator as shown in Figure 19. The main reference milestones are the Preliminary Design Review (PDR) and the Critical Design Review (CDR) and therefore relevant results and outcomes from this activity have to be provided in advance to these review meetings.

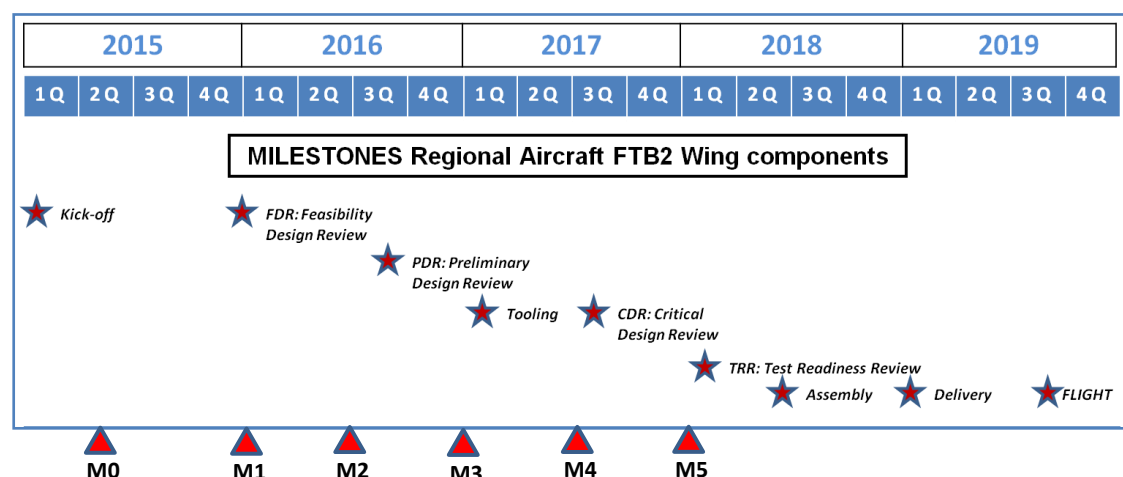


Figure 19: Milestones for the Regional Aircraft FTB2 and related Milestones (M1 to M5) of the CfP (at the bottom line)

The Deliverables and Milestones are correlated to the different tasks as described in the previous section and are provided in the following two tables. Principal dates in accordance to FTB#2 schedule:

- The starting time T0 is estimated to be January of 2016 (M0)
- Low Reynolds Wind Tunnel Tests start date September 2016 (M7)
- High Reynolds Wind Tunnel Tests start date June 2017 (M10)

The schedule is an estimation based on the best information at the time of the topic publication. Airbus DS will inform about potential updates and interfaces with works in the IADP (i.e. leaders and other partners contribution) during negotiation phase.

Milestones (when appropriate)		
Ref. No.	Title - Description	Due Date
M0	Project Kick-off	T0
M1	Requirements and Specifications	T0+1M
M2	Release of the complete WTM design at the baseline configuration	T0+5M
M3	Release of the design of a first set (Design 1) of new control devices (winglet, flaps, spoiler, aileron, leading edge)	T0+7M
M4	Baseline PwOff WTM manufactured (complete set of items of the reference model)	T0+8M
M5	Baseline PwOn WTM manufactured (complete set of items of the propulsive system and power supply)	T0+8M
M6	Release of the new control devices manufactured (winglet, flaps, spoiler, aileron, leading edge) Design 1 (initial design and concept)	T0+9M
M7	Interfaces to Low-Re WTT	T0+9M
M8	Release of the design of the Design 2 (final design) of the new control devices	T0+15M
M9	Release of the new control devices manufactured (winglet, flaps, spoiler, aileron, leading edge). Design 2 (final design)	T0+17M
M10	Interfaces to Hi-Re WTT	T0+18M

Table 2: List of Milestones.

Deliverables			
Ref. No.	Title - Description	Type	Due Date
D1	Baseline WTM design	Data files & Documents	T0+5M
D2	Design of the first set (Design 1 –initial design and concept-) of new control devices (winglet, flaps, spoiler, aileron, leading edge)	Data files & Documents	T0+7M
D3	Design of the second set (Design 2 –final design-) of new control devices (winglet, flaps, spoiler, aileron, leading edge)	Data files & Documents	T0+9M
D4	Baseline PwOff WTM (complete set of items of the reference model manufactured and assembled)	Data files & Documents + manufactured items & assembly	T0+8M
D5	New devices manufactured items (winglet, flaps, spoiler, aileron, leading edge) Design 1	Data files & Documents+ manufactured items	T0+9M

Deliverables			
Ref. No.	Title - Description	Type	Due Date
D6	New devices manufactured items (winglet, flaps, spoiler, aileron, leading edge) Design 2	Data files & Documents+ manufactured items	T0+15M
D7	PwOn complete system (complete set of items of the propulsive system and power supply)	Data files & Documents+ manufactured items	T0+8M
D8	Interfaces to Low-Re WTT	Data files & Documents+ manufactured items	T0+6M
D9	Interfaces to Hi-Re WTT	Data files & Documents	T0+18M

Table 3: List of Deliverables.

4.

5.

6. Special skills, Capabilities, Certification expected from the Applicant(s)

- Knowledge and experience in experimental processes linked to aeronautical projects and related to:
 - Wind tunnel testing
 - Wind tunnel means and facilities
 - Wind tunnel models design
 - Wind tunnel models manufacturing
 - Wind tunnel test instrumentation and measurements
 - Propulsive simulators for WTM, specially involving propellers and open rotors
- Involvement with design offices of the airframe industry and a/c engines industry
- Experience with WTT campaigns of turboprop driven A/C type
- Participation in R&T projects cooperating with industrial partners.
- Experience in technological research and development in aerodynamics fields.
- Capacity of evaluating results in accordance to Horizon 2020 productivity goals following Clean Sky 2 Technology Evaluator rules and procedures.

7. Abbreviations

6DOF	6 Degrees of Freedom
AoA	Angle of Attack
CAD	Computed Aided Design
CAE	Computed Aided Engineering
CFD	Computational Fluid Dynamics
CT	Thrust Coefficient
CfP	Call for Proposal
CTD	Capability and Technology Domain
ADS	Airbus Defence and Space
EADS-CASA	European Aeronautics Defense and Space
SAU	Sociedad Anonima Unipersonal
EASA	European Aviation of Safety Agency
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulations
FT	Flight Tests
FTB2	Flight Test Bed 2
HQ	Handling Qualities
IADP	Innovative Aircraft Demonstrator Platforms
ITD	Integrated Technology Demonstrator
JTP	Joint Technical Proposal
OAD	Overall Aircraft Design
R&T	Research and Technology
REG	Regional Platform of Clean Sky 2
STM	Strategic Topic Manager
TRL	Technology Readiness Level
WBS	Work Breakdown Structure
WT	Wind Tunnel
WTM	Wind Tunnel Model
WTT	Wind Tunnel Tests

1.3. Clean Sky 2 – Fast Rotorcraft IADP

I. Development and demonstration of materials and manufacturing process for ultra high reliability electric Anti-ice/De-ice thermal layers for high strain rotor blades and airframe sections of a civil tilt-rotor

Type of action (RIA or IA)	IA		
Programme Area	FRC (Tilt-Rotor)		
Joint Technical Programme (JTP) Ref.	WP Level 1 – FRC 1.1 and 1.6		
Indicative Funding Topic Value (in k€)	750 k€		
Duration of the action (in Months)	48 months	Indicative Start Date ¹⁸	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-FRC-01-01	Development and demonstration of materials and manufacturing process for ultra high reliability electric Anti-ice/De-ice thermal layers for high strain rotor blades and airframe sections of a civil tilt-rotor
Short description (3 lines)	
The objective is to develop heater layers to be embedded in composite structures to provide anti-icing and de-icing capability where safety requirements dictate ultra high reliability, while operating in high strain and vibration conditions. Structural and environmental testing will be conducted on representative test items consisting of functional heater layers embedded in the proprotor blades and airframe sections of a tilt-rotor configuration intended for civil certification.	

¹⁸ The start date corresponds to actual start date with all legal documents in place.



1. Background

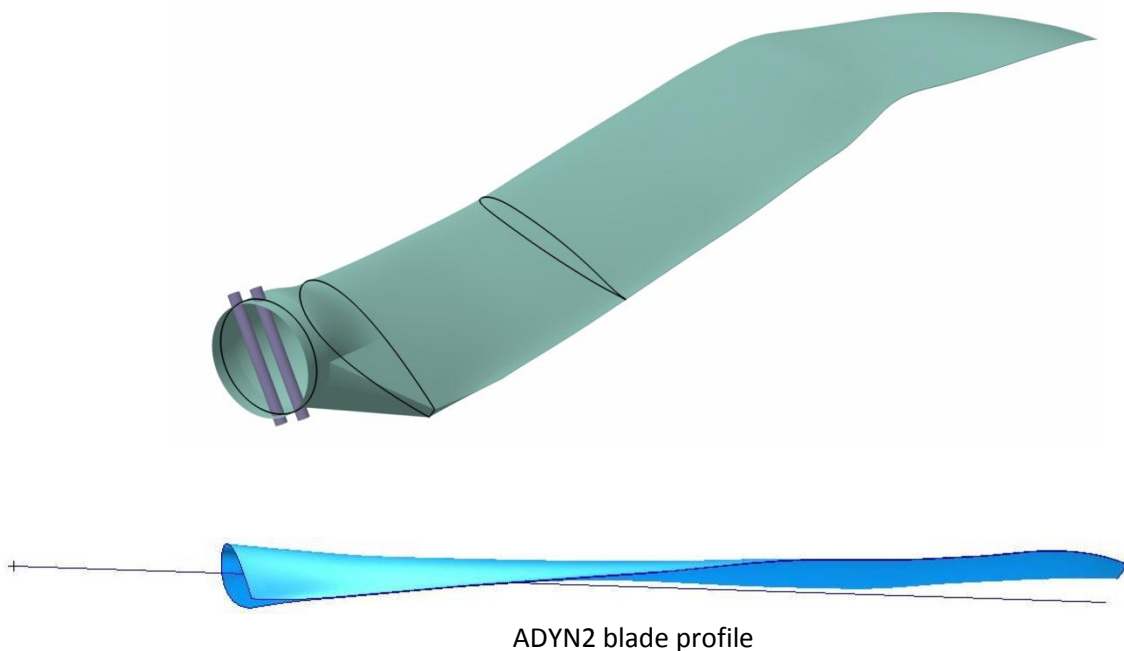
The aim of the Fast Rotorcraft (FRC) project is to use technologies developed through the Clean Sky Programme to demonstrate a compound rotorcraft configuration that combines the vertical lift capability of the conventional helicopter with the speed capability of a fixed wing aircraft in a sustainable way.

The outcome of this project is structural and environmental test substantiation of ultra high reliability heater layers which are capable to be integrated into an advanced civil rotorcraft configuration with high cruise speed, low fuel consumption and gas emission, low community noise impact, and high productivity for operators.

2. Scope of work

This Call is for Partners to perform design, manufacture, test and associated project management activities to produce an ultra-high reliability heater layer for ice protection of proprotors and composite fixed surfaces such as wing leading edge, horizontal stabilizer/vertical fin and fairings.

In particular for rotor applications, in addition to the high strain environment that a heater layer must withstand in a conventional helicopter rotor blade; a heater layer in a proprotor blade must also have the structural integrity to withstand a high twist over a short span. An example of a proprotor blade profile and high twist from a previous European joint programme (ADYN2, from the NICETRIP project) are shown in the images below.



Tasks		
Ref. No.	Title - Description	Due Date
T0	Project Management	T0-T48
T1	Design and Development of an anti-icing/de-icing heater layer to be incorporated into a propotor or panel composite structure.	T0-T18
T2	Manufacture of heater layer	T14-T24
T3	Manufacture of structural element test specimen incorporated into AgustaWestland manufactured propotor or panel composite structure	T24-T30
T4	Manufacture of environmental test specimen incorporated into AgustaWestland manufactured propotor or panel composite structure	T24-T36
T5	Endurance Testing including static and fatigue of structural specimen	T30-T42
T6	Environmental spin rig testing of propotor with integrated heater layer in icing wind tunnel	T36-T42
T7	Reporting of structural test results	T42-T48
T8	Reporting of Environmental test results	T42-T48

Where applicable detailed aspects of tasks are given in the following paragraphs:

Task T0:

Accounts for management activities throughout the duration of the project.

Task T1:

Heater layer design features to be optimised:

- Reliability of 0.5×10^{-9} per flight hour
- Minimum weight to meet required life and functionality
- Lightning Strike Strength/Behaviour shall not be affected
- Thickness of heater layer (including insulation on the composite side) $\leq 2.00\text{mm}$
- The materials choice shall take into account the REACH initiative from the European Chemical Agency.
- Unlimited fatigue life (or at least the $>$ fatigue life of the spar) demonstrated by test for the heater layer, support material, heated elements, busbars and connections with the following strain conditions:

Mean	Dynamic
2800 $\mu\epsilon$	1500 $\mu\epsilon$
- Where applicable, heater layer interface materials shall be such to allow bonding to spar and erosion shield materials.
- Ultimate Static strength for the heater mats (support material, resistors and temperature sensors) without loss of de-ice capability prior to failure:
 - Tension: $\sim 12000 \mu\epsilon$ or higher.
 - Compression: $\sim 8000 \mu\epsilon$ or higher
- Maximum temperature at the heater layer to structure interface of $< 90^\circ\text{C}$
- Heater mat operational temperature range: -55°C to $+10^\circ\text{C}$
- Coupon tests shall be carried out for both structural and electrical continuity.

- Electrical and thermal isolation. Consideration should be given to adequate static discharge.
- A preliminary analysis shall be presented to show the improvements of the proposed heater mats configuration with respect to present heater mats generation in term of minimisation of the power density required to keep free from ice the protected surfaces
- Ease of replacement/repair procedure should be built into the design for the heater layer

Task T5:

The Partner will demonstrate by test the fatigue and static strength capability of the heater layer and associated connections. In addition to the static and fatigue testing, capability to withstand the vibration environment will be demonstrated.

Task T6:

Structural and reliability spin rig testing to be conducted by the Partner of a heater layer integrated into a propotor blade specimen under representative conditions for ice acumulation and the strain environment associated to the working frequency of the rotor.

General Remarks:

Development of the heater layer will be conducted in close cooperation with the Topic Manager.

All correspondence and technical proposals shall be written in English. Where the originals of any document are in a language other than English.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
D1	Concept	Document/Report	T0+12
D2	Detailed Drawings	Document/Report	T0+18
D3	Heater Layer for test specimen	Hardware	T0+24
D4	Heater layer integrated into structural test specimen (propotor or panel composite structure)	Hardware	T0+30
D5	Heater layer integrated into environmental test specimen (propotor or panel composite structure)	Hardware	T0+36
D6	Full Assessment of structural test results	Document/Report	T0+48
D7	Full Assessment of environmental test results	Document/Report	T0+48

Milestones			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
M1	PDR	Milestone	T0+8
M2	CDR	Milestone	T0+12
M3	Structural test specimen incorporating heater layer available	Milestone	T0+30
M3	Environmental test specimen incorporating heater layer and controls available	Milestone	T0+36
M4	Structural test report issued	Milestone	T0+48
M5	Environmental test report issued	Milestone	T0+48

NOTE: Deliverables and Milestones listed in the above tables are intended to be part of the technical data exchange between the selected CfP candidate and the Topic Leader (AW), while the contractual milestones and deliverables, and related terms of agreements, between the selected CfP candidate and the JU will be detailed and mutually agreed during the Negotiation Kick-off meeting phase.

4. Special skills, Capabilities, Certification expected from the Applicant(s)

The Topic Manager is responsible in front of the airworthiness agency and it is therefore mandatory that the Topic Manager will be supported by the Partner with respect to all qualification related activities in relation the heater layer and the constituent materials . Therefore the Partner has to provide all documentation necessary to achieve structural and environmental test substantiation, including:

- Material data which are required to achieve a “Permit to Fly”.
- Using material, processes, tools, calculation tools etc. which are commonly accepted in the aeronautic industry and by certification authorities.
- Harmonization (through Topic Manager) of calculation processes/tools.
- Interacting with the Topic Manager at any state of work.
- Access to production and test facilities.
- It is expected, that latest 2015 TRL level 4 is achieved for each system/technology proposed.
- If this is not achieved on time, Partner has to initiate a mitigation plan how to reach the target of TRL 6 at the end of demonstration.
- The Partner has to perform the updates of documentation in case of in-sufficient documentation for authorities.

Special Skills

- Experience in design and manufacture of heating elements in advanced composite structures.
- Access to and experience using Aerospace industry standard design, analysis and configuration management tools (CATIA v5, Abaqus, VPM).
- Proven competence in management of complex research, development and manufacturing activities
- Proven capability to perform non linear stress and strain analysis (materials and displacement).
- Access to production and test facilities.
- Analytical vs Experimental correlation capability
- Proven experience in collaborating with O.E.Ms of flight vehicles is desirable.
- Capacity to perform Life Cycle Analysis (LCA) and Life Cycle Cost Analysis (LCCA) of materials and structures
- Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004)

II. Development and demonstration of materials and manufacturing process for high power density homokinetic drive joints for civil rotor applications

Type of action (RIA or IA)	IA		
Programme Area	FRC (Tilt-Rotor)		
Joint Technical Programme (JTP) Ref.	WP Level 1 – FRC 1.1 and 1.2		
Indicative Funding Topic Value (in k€)	750 k€		
Duration of the action (in Months)	48 months	Indicative Start Date ¹⁹	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-FRC-01-02	Development and demonstration of materials and manufacturing process for high power density homokinetic drive joints for civil rotor applications
Short description (3 lines)	
The objective is to deliver flight cleared homokinetic drive units for civil tiltrotor proprotor units. Representative test items will be used for structural and environmental testing and the flight cleared components will be integrated in the tiltrotor rotor system.	

¹⁹ The start date corresponds to actual start date with all legal documents in place.



1. Background

The aim of the Fast Rotorcraft (FRC) project is to use technologies developed through the Clean Sky Programme to demonstrate a tiltrotor configuration that combines the vertical lift capability of the conventional helicopter with the speed capability of a fixed wing aircraft in a sustainable way.

The outcome of this project is substantiation of a flight cleared homokinetic drive unit integrated into a proprotor system. This will form part of an advanced rotorcraft configuration with high cruise speed, low fuel consumption and gas emission, low community noise impact, and high productivity for operators. A large scale flightworthy demonstrator embodying the new European tiltrotor architecture will be designed, integrated and flight tested.

2. Scope of work

This Call is for Partners to perform design, manufacture, test and associated project management activities to produce a flightworthy homokinetic drive unit as part of the FRC demonstrator configuration.

The compact drive unit will have to transmit torque at constant RPM while accomodating a range of propotor flaping motion and any transient torque from flight manouvres.

The required tasks with assosiated Deliverables and Milestones are presented in the following tables:

Tasks		
Ref. No.	Title - Description	Due Date
T0	Project Management	T0-T0+48
T1	Design and Development of a homokinetic drive unit.	T0-T0+12
T2	Manufacture of Test specimens for characterisation and structural testing	T0+12-T0+24
T3	Characterisation testing	T0+24-T0+30
T4	Structural endurance testing	T0+24-T0+36
T5	Updating of the homokinetic drive unit according to the evolution of the overall rotor design	T0+24 -T0+40
T6	Manufacture of flight hardware	T0+40 -T0+46
T7	Support to obtaining Flight Clearance	T0+40 -T0+48

Further details related to specific activities are given below:

Task T0:

Accounts for ongoing project management of the programme.

Task T1:

The design requirements to be fulfilled by Task 1 are as follows:

- Reference Max continuous power:
5000 shp
- Transient power capability:
10000 shp
- Minimum working RPM:
450-500 RPM
- Space envelope:
Diameter < ~350mm
- Maximum motion range:
 $\pm 10^\circ$ Flapping
- Minimum weight to fulfil functional requirements

**Task T2:**

At least four (4) representative specimens, (two (2) for characterisation testing and two (2) for structural testing) will be manufactured to be tested at a location agreed between the Partner and the Topic Manager.

General Remarks:

Integration into the overall rotor design will be an ongoing activity to ensure acceptable dynamic performance of the drive unit and that Geometric and kinematic clearance between rotor system components are maintained.

Development of the homokinetic unit will be conducted in close cooperation with the Topic Manager.

All correspondence and technical proposals shall be written in English. Where the originals of any documents submitted are in a language other than English, a translation will be provided.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
D1	Concept	Document/Report	T0+8
D2	Detailed Drawings	Document/Report	T0+12
D3	Availability of Specimen for Characterisation Testing	Hardware	T0+24
D4	Availability of Specimen for Endurance Testing	Hardware	T0+24
D5	Assessment of dynamic characteristics	Document/Report /Presentation	T0+30
D6	Interim assessment of Endurance Testing	Hardware	T0+30
D7	Availability of flight hardware	Hardware	T0+46
D8	DDP for Flight Clearance	Document/Report	T0+48

Milestones (when appropriate)			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
M1	PDR	Design Review	T0+8
M2	CDR (TRL of at least 5 for each system, technology and manufacturing process proposed)	Design Review	T0+12
M3	Availability of test specimens for endurance and characterisation testing	Hardware Availability	T0+24
M4	Interim Endurance test report	Document	T0+30
M5	Installation of flight hardware into Rotor Assy	Hardware Availability	T0+48
M6	Flight Clearance (TRL-7 for each system, technology and manufacturing process)	Flight Readiness Review	T0+48

NOTE: Deliverables and Milestones listed in the above tables are intended to be part of the technical data exchange between the selected CfP candidate and the Topic Leader (AW), while the contractual milestones and deliverables, and related terms of agreements, between the selected CfP candidate and the JU will be detailed and mutually agreed during the Negotiation Kick-off meeting phase.

4. Special skills, Capabilities, Certification expected from the Applicant(s)

The Topic Manager is responsible in front of the airworthiness agency and it is therefore mandatory that the Topic Manager will be supported by the Partner with respect to all qualification related activities in relation the flexbeam and the constituent materials . Therefore the Partner has to provide all documentation necessary to achieve “Permit to Fly”, including:

- Material data which are required to achieve a “Permit to Fly”.
- Using material, processes, tools, calculation tools etc. which are commonly accepted in the aeronautic industry and by certification authorities.
- Approach to calculation methods and the tools used will be agreed between the Partner and Topic Manager to ensure harmonisation of calculation processes/tools.
- Interaction with the Topic Manager at each stage of development.
- Access to production and test facilities.
- It is expected, that by T0+12, at least TRL 4 is achieved for each system/technology proposed.
- If this is not achieved on time, the Partner has to initiate a mitigation plan how to reach the target of TRL 7 at the end of the programme.
- The Partner has to perform the updates of documentation in case of in-sufficient documentation for authorities.

Special Skills

- Competence in management of complex projects of research and manufacturing technologies.
- Experience in design and manufacturing of constant velocity joints.
- Design, analysis and configuration management tools of the aeronautical industry (i.e. CATIA v5 release 21, Abaqus, VPM)
- Analytical vs Experimental correlation capability
- Experience with TRL Reviews or equivalent technology readiness assessment techniques in research and manufacturing projects for aeronautical or automotive industry
- It is desirable to have proven experience in collaborating with reference aeronautical companies with industrial air vehicle developments with “in – flight” components experience.
- Capacity to support documentation and means of compliance to achieve experimental prototype “Permit to Fly” with Airworthiness Authorities (i.e. EASA, FAA and any others which may apply).
- Capacity to specify material and structural tests along the design and manufacturing phases of aeronautical components, including: material screening, and instrumentation.
- Capacity to perform structural and functional tests of aeronautical components: test preparation and analysis of results
- Capacity to repair “in-shop” components due to manufacturing deviations.
- Capacity of performing Life Cycle Analysis (LCA) and Life Cycle Cost Analysis (LCCA) of materials and structures.
- Capacity of evaluating design solutions and results along the project with respect to Ecodesign rules and requirements.
- Design Organization Approval (DOA) is desirable
- Product Organization Approvals (POA) is desirable

- Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004)
- Qualification as Material and Ground Testing Laboratory of reference aeronautical companies (i.e. ISO 17025 and Nadcap).
- Advanced Non Destructive Inspection (NDI) and components inspection to support new processes in the frame of an experimental Permit to Fly objective.

Material and Processes

In order to reach the main goals of the project two major aspects have to be considered for materials and processes, namely: maturity and safety.

Because of the ambitious plan to develop a flying prototype in a short time frame, the manufacturing technology of the partner must be on a high maturity level (TRL4) at the start of the project in order to be able to safely reach the required technology readiness for the flying demonstrator.

To secure this condition, the Partner will have to demonstrate the technology readiness of proposed materials and process and manufacturing technology with a TRL review, to be held together with the Topic Manager.

The TRL review must be held within one year after beginning of the project and must confirm a maturity of TRL5 or at least TRL4 if a solid action plan to reach TRL5 within the scope of one further year and finally meet the TRL target for the demonstrator, validated and accepted by the Topic Manager. Since the schedule of the project and the budgetary framework do not allow for larger unanticipated changes in the middle of the project, it is required that at the start of activities the partner demonstrates capability to develop and manufacture the required items with a baseline technology which will be a back-up solution if the new technology to be introduced proves to be too challenging.

This back-up plan, which shall secure the meeting of the project goals shall also be agreed between AW and the Partner within six months after start of the activities and approved by the JU.

Furthermore the management and planning activities in this Call shall support the safe inclusion of the developed technology into the complete flying Nect GenCTR Demonstrator.

III. Development and validation of an optimised gearbox housing structural design and manufacturing process, based on additive layer manufacturing concept leading to a flight cleared demonstrator.

Type of action (RIA or IA)	IA		
Programme Area	FRC (Tilt-Rotor)		
Joint Technical Programme (JTP) Ref.	WP Level 1 – NextGenCTR Demonstrator Tiltrotor Project		
Indicative Funding Topic Value (in k€)	1750 k€		
Duration of the action (in Months)	60 months	Indicative Start Date²⁰	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-FRC-01-03	Development and validation of an optimised gearbox housing structural design and manufacturing process, based on additive layer manufacturing concept leading to a flight cleared demonstrator.
Short description (3 lines)	
Design of a novel Tiltrotor Drive System housing, by means of Additive Layer Manufacturing (ALM) techniques (i.e. Direct Metal Laser Sintering), definition of the optimised manufacturing process and construction of an appropriate number of specimens and parts to support flight clearance on the NextGenCTR Demonstrator. The development of ALM materials characterised by suitable mechanical and fatigue properties, as well as the development of optimisation tools for ALM component design and structural substantiation, will be part of the activities.	

²⁰ The start date corresponds to actual start date with all legal documents in place.



1. Background

Within the scope of Clean Sky 2 Fast Rotorcraft (FRC) Innovative Aircraft Demonstrator Platform (IADP) framework, the Next Generation Civil Tiltrotor project (NextGenCTR) is aimed at designing, building and flying a technology demonstrator to validate an innovative tiltrotor concept, the configuration of which will go beyond current architectures of this type of aircraft. In summary, this concept will involve tilting prop-rotors mounted in fixed nacelles at the tips of relatively short wings, consisting of a fixed inboard and a tilting outboard portion next to the nacelle. The tilting portion will move in coordination with the prop-rotors, to minimize rotor downwash impingement in hover and increase efficiency. The demonstration activities of the NextGenCTR IADP aim at validating the proposed architecture, technologies, systems and operational concepts to prove significant improvements with respect to the current state-of-the-art for tiltrotor concepts. The project will also allow developing substantial R&T activities to increase the know-how about tiltrotors and to generate steady, high volume research and innovation activities comparable to that of well proven helicopter platforms.

In addition to the IADP for complex vehicle configurations, the Clean Sky 2 project defines also the so-called Integrated Technology Demonstrators (ITDs) that will accommodate the main relevant technology streams for all air vehicle applications. They allow the maturing of verified and validated technologies from their basic levels to the integration of entire functional systems. They have the ability to cover quite a wide range of technology readiness levels. Further details regarding the Clean Sky 2 Project are described into the Clean Sky 2 Joint Technical Programme (V5).

The Call proposal from applicants for the role of Partner, described in the present document, is part of the NextGenCTR FRC IADP and in particular is managed within the Workpackage 1.3 “Highly Reliable, Safe & Environmentally Friendly Drive System” in accordance with the Clean Sky 2 Joint Technical Programme Rev. 5, paragraph 8.6.8. Aim of this WP is the design, manufacturing and testing at component level of an innovative drive system for the NextGenCTR. The research targets safe and reliable design, low environmental impact, low production and operational costs. In particular, the object of this Call is the design of a novel tiltrotor drive system housing by means of additive manufacturing process.

As known, the so-called additive manufacturing (AM) technologies allow to build near-net shape components, one layer at a time, using data directly from 3D CAD models. The possibilities associated to this kind of technology can be summarized in reducing component lead time, cost, material waste, energy usage, and carbon footprint. The first (and probably most evident) benefit of this technology is the reduction of the time needed for prototyping. Nevertheless, due to the noteworthy associated costs, the most valuable and unique advantage associated to the additive concept is the potential to enable novel product and designs that could not be manufactured using conventional subtractive techniques. In addition, using AM to fabricate metal parts opens the possibility for reducing material usage that could enable overall reduction in cost and greenhouse gas emissions related to manufacturing, within the concept of “green manufacturing”.

The present document describes the main activities to be performed, the general time-scheduling, the expected results and deliverable as well as the general requirements that JU shall consider for the selection of the appropriate Partner(s).

2. Scope of work

The activity, object of this Call, is aimed to:

- design of an optimised tiltrotor drive system housing, by means of additive manufacturing process. The development of suitable optimisation software/tools for ALM component design and structural substantiation will be part of the activities;
- develop a dedicated materials in terms of composition and structure (matrix and filler), appropriated for ALM technology and characterised by suitable mechanical and fatigue properties. Indeed ALM technique involves a new and different method of thinking for designing, without the compromises imposed by process limitations: therefore the creation of a complex internal lattice structures within a 3D part, to reducing material volume and weight, can be conceived;
- define the optimised manufacturing process and the relative quality and inspection procedures to guarantee the fit, form and functional requirements fulfilment;
- realize an appropriate number of specimens and parts to support flight clearance on the NextGenCTR Demonstrator.

Tasks		
Ref. No.	Title – Description	Due Date [T0 + mm]
T1	Feasibility Study and Preliminary Design Trade-off analysis across existing and emerging ALM technologies, concept exploration starting from drive system component requirements in terms of material properties, functional and structural aspects, interfaces and quality assurance. Main goal: definition of ALM material characteristic and the production process requirements. Identification of the best candidates for the following phase.	T0+12
T2	Material Characterization Plan Detailed definition of the material characteristics and experimental evaluation of its micro-structural and mechanical properties.	T0+44
T3	Detailed Design and Process Development Definition and development of the HW: two different components (one relative small and one main housing) will be analyzed. Production cycles, quality procedures and checks will be defined; The final design will be the result of a topological structural optimization. The definition of the analysis approach and methodologies (software and tools) is part of the activity.	T0+52
T4	Prototype and pre-production evaluation Manufacturing of the optimized components; support to the full-scale test phase aimed to achieve the flight clearance of the NextGenCTR demonstrator. Start-up of the production phase	T0+60

Task 1 – Feasibility Study and Preliminary Design

Ref. No.	Title - Description	Due Date
1.1	Component and process requirement review	T0+12
1.2	ALM process and material concept definition	T0+12

This phase will enable to settle all data necessary to reach the specification requirements. The main challenge is to envisage a suitable material and component design that meet all the requirements and boundary conditions defined by the NextGenCTR drive system layout. A joint Concept Review will be set-up at the end of the phase 1. During this review, held by AW and the selected Partner(s), the following topics should be considered:

- Preliminary architecture and AM process definition for development;
- Preliminary definition of the material (matrix, filler and structure) tailored to a lightweight, resistant and reliable design. To develop a custom material, lattice structures and light metal matrix composites, suitable for the ALM processes, could be envisaged;
- Benefits assessments based on simulation of performance, cost, weight, safety, etc. Support of this trade-off in collaborative manner with AgustaWestland simulation lifecycle management framework is a plus, though not mandatory.
- Components risk mitigation plan;
- Identification of the component to be designed in detailed. Taking into account the current limitation for the ALM overall dimensions, the production of both a single component and/or a welded part should be investigated;
- Tasks 2, 3 and 4 detailed plan.

Task 2 – Material Characterization		
Ref. No.	Title - Description	Due Date
2.1	Specimen Test Campaign	T0+44
2.1.1	<i>Test Specimen Definition and Samples Production</i>	T0+12
2.1.2	<i>Static and Fatigue properties characterization</i>	T0+24
2.1.3	<i>Flaw tolerance and Crack growth characterization</i>	T0+36
2.1.4	<i>Welding process</i>	T0+36
2.1.5	<i>Corrosion and compatibility (oil, painting, primer)</i>	T0+44
2.2	Prototype and test of a drive system component	T0+20

To be confident about designing with ALM technological process and the material selected, the evaluation of the effects of the laser sintering parameters on the surface, micro-structural and mechanical properties of the final components is fundamental. The material characterization task is aimed to investigate all these aspects, by means of non-destructive and destructive tests (i.e. computer tomography, 3D scanner, optical and electron microscopy inspections, X-ray diffraction checks, micro-hardness tests, standard mechanical tests). The characterization of the mechanical properties of the material selected for component design represents the primary goal of this plan. Mechanical properties will be investigated performing a suitable test campaign on material coupons, aimed to identify static and fatigue limit of the material both in pristine condition and in presence of defects. Material characterization will lead to an extensive test campaign, by means of tensile tests, charpy v-notch impact tests and rotating bending fatigue tests.

Once frozen the process and the material to be used, a detailed threat assessment shall be performed to define all the possible threats by which the components realized with additive layer manufacturing processes are likely to be affected. Hazards and associated flaws/damages location, size and type will be accounted by the fatigue substantiation procedures in order both to take into consideration and evaluate the presence of intrinsic flaws and to determinate the fatigue crack propagation behaviour. Dedicated flaw tolerance and crack growth tests will be performed. Compliance to flaw tolerance requirements is mandatory for civil application and it is part of the base of certification. In addition also the effect of the welding process on the mechanical properties of the material will be investigated.

All the characterization tests will be carried out according to AgustaWestland procedures and standards. As such reduction of latter campaign, test data, leading to mechanical properties, will have to be supported by a fully traceable process, monitorable by AgustaWestland materials data management system. In order to reduce financial and time impact incurred by physical test, capability to virtualize characterizations of some of the mechanical properties, especially when associated to their evolution along the welding process, would represent a strong asset to the overall project objectives.

In parallel to the above-mentioned tests on dedicated specimens, in order to mitigate the risk associated to the ALM process definition and to guarantee the compliance of this technique with the functional aspects of a conventional helicopter housing, an already existing design of an helicopter drive system component will be produced, manufactured with ALM technique. A dedicated full-scale test performed by AgustaWestland laboratory, is conceived to achieve the manufacturing proof of concept.

Task 3 – Detailed Design and Process Development		
Ref. No.	Title - Description	Due Date
3.1	Design and structural optimization	T0+52
3.2	Methodologies for design, optimization and structural substantiation of ALM components	T0+52

The preliminary design selected within the scope of Task 1 will be optimized with a topological structural optimisation process. Design methodology definition and the advanced material finite element modeling, by means of realistic representative volume elements, is the core of the task 3 activities.

Simulation process will have to achieve adequate Technology Readiness Level beyond pure demonstrator status to be approved as a mean for certification. Such a validation will be greatly facilitated if the FE framework used has already such a status in the Aerospace Industry and specifically in AgustaWestland simulation engineering and design department .CF Stress tools skills.

Task 4 – Prototype and pre-production evaluation		
Ref. No.	Title - Description	Due Date
4.1	Full-scale components manufacturing	T0+56
4.2	Structural and Functional Tests support	T0+60
4.3	Production start-up	T0+60

In addition to the prototyping of the full-scale components also the definition of the needed procedures and processes (engineering cost and industrial capability assessment) for the start-up of the high volume production phase is required.

Task Breakdown and Planning

Month	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	
T1.1: Component and process requirement review																
T1.2: ALM process and material concept definition																
T2.1: Specimen Test Campaign																
T2.2: Prototype and test of a drive system component																
T3.1: Design and structural optimization																
T3.2: Methodologies for design, optimization and structural substantiation of ALM components																
T4.1: Full-scale components manufacturing																
T4.2: Structural and Functional Tests support																
T4.3: Production start-up																

Project Organization

A project task leader, an engineering interface team and an expertise consultancy team, if required, shall be identified. The task leader manages the project, being in charge of the elaboration of the Project Master Plan. He is the focal point for the project and will ensure the correct progress. The project leader also provides guidance to both expert consultancy and engineering teams, validates key milestones deliverables and authorizes transition to further development phases. The engineering team is in charge of the technical activities, while the expert consultancy team, if any, will assist the engineering team providing support on the different technical, operational and industrial aspects availing of their relevant experience and know-how in the areas where support is required.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type	Due Date
T1.D1	Component & Process Requirement Review meeting MoM	Document	T0+4
T1.D2	ALM process and material concept definition acceptance by AW	Document	T0+8
T1.D3	Concept Review meeting MoM	Document	T0+8
T1.D4	Preliminary Design Review meeting MoM	Document	T0+12
T2.D1	Material Characterization Test Plan Proposal acceptance by AW	Document	T0+9
T2.D2	Material Characterization Test Phase PDR meeting MoM	Document	T0+9
T2.D3	Material Characterization Test Phase CDR meeting MoM	Document	T0+11
T2.D4	Specimen Drawings (approved by AW)	Document	T0+9
T2.D5	Specimen Production delivered to AW	Production	T0+12
T2.D6	Material Tests Readiness Review meeting MoM	Document	T0+12
T2.D7	Material Characterization Test Report acceptance by AW	Document	T0+44
T2.D8	Current Design Housing manufactured with ALM process delivered to AW	Production	T0+20
T3.D1	Technical drawings (approved by AW)	Document	T0+44
T3.D2	Production cycles (approved by AW)	Document	T0+48
T3.D3	Optimisation process procedure	Document	T0+28
T3.D4	Structural substantiation of the new design proposals approved by AW	Document	T0+44
T3.D5	Acceptance and inspection criteria acceptance by AW	Document	T0+44
T3.D6	Preliminary test phase review meeting MoM	Document	T0+36
T3.D7	Critical Design Review meeting MoM	Document	T0+44
T4.D1	ALM Prototypes delivered to AW	Production	T0+52
T4.D2	Test Plan Proposal acceptance by AW	Document	T0+48
T4.D3	Test Phase Review meeting MoM	Document	T0+48
T4.D4	Tests Readiness Review meeting MoM	Document	T0+56
T4.D5	Test Report acceptance by AW	Document	T0+60
T4.D6	Flight Clearance Document acceptance by AW	Document	T0+60

Milestones (when appropriate)			
Ref. No.	Title - Description	Type	Due Date
T1.M1	Component & Process Requirement Review meeting	Meeting	T0+4
T1.M2	Concept Review meeting	Meeting	T0+8
T1.M3	Preliminary Design Review meeting	Meeting	T0+12
T2.M1	Material Characterization Test Phase PDR meeting	Meeting	T0+9
T2.M2	Material Characterization Test Phase CDR meeting	Meeting	T0+11
T2.M3	Specimen availability	Production	T0+12
T2.M4	Material Characterization Tests Readiness Review meeting	Meeting	T0+12
T2.M5	Structural / Functional Tests execution	Test	T0+44
T2.M6	Current Design Housing availability	Production	T0+20
T3.M1	Technical drawings availability	Documents	T0+44
T3.M2	Production cycles availability	Documents	T0+48
T3.M3	Preliminary Test Phase Review meeting	Meeting	T0+28
T3.M4	Critical Design Review meeting	Meeting	T0+44
T4.M1	ALM Prototypes availability	Production	T0+52
T4.M2	Test Phase Review meeting	Meeting	T0+48
T4.M3	Tests Readiness Review meeting	Meeting	T0+56
T4.M4	Structural / Functional Tests execution	Test	T0+60
T4.M5	Flight clearance approved by AW	Documents	T0+60

NOTE: Deliverables and Milestones listed in the above tables are intended to be part of the technical data exchange between the selected CfP candidate and the Topic Leader (AW), while the contractual milestones and deliverables, and related terms of agreements, between the selected CfP candidate and the JU will be detailed and mutually agreed during the Negotiation Kick-off meeting phase.

4. Special skills, Capabilities, Certification expected from the Applicant(s)

The Applicant(s) (company or consortium) shall describe its experience/capacities in the following subjects:

- ❑ Experience in design and sizing of structural components by means of ALM techniques
- ❑ Proven capability and experience in manufacturing and testing of ALM components. Experience in aeronautical business sector is preferred
- ❑ Proven capability and experience in testing, developing and supporting the material characterization tests (static and fatigue)
- ❑ Expertise in test data reduction management and virtualization of mechanical properties in a collaborative manner with SimManager (preferred), as AgustaWestland Simulation Lifecycle Management
- ❑ Capacity and experience in tests definition and preparation: stress and strain predictions, deflection prediction and instrumentation definition
- ❑ Tools for design and stress analysis. Experience in the aeronautical business sector is preferred (i.e. CATIA v5, NASTRAN or equivalent)
- ❑ Proven capability and experience in complex and composite material FE simulation
- ❑ Proven capability and experience in structural, shape and topological optimization
- ❑ Experience in integration multidisciplinary teams in concurrent engineering. Experience in aeronautical business sector is preferred
- ❑ Experience in technological research and development for innovative processes
- ❑ Participation in international R&T projects cooperating with industrial partners, institutions, technology centres and universities.
- ❑ Proven experience in collaborating with reference aeronautical companies Research and Technology programs

Manufacturing capability and equipment:

Following list gives an overview of possible and well known manufacturing equipment but can be appended by Partner(s) approved technologies:

- ❑ Facilities and machines for ALM production;
- ❑ Non destructive inspection capabilities and required equipment (i.e. eddy current, ultrasonic, X-ray, Tomography, magnetic, nital etch, dimensional inspection systems);
- ❑ Testing facilities (availability of dedicated bench test rigs for functional and structural tests)

Certification (preferred):

- ❑ Design Organization Approval (DOA).
- ❑ Product Organization Approvals (POA).
- ❑ Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004)
- ❑ Qualification as strategic supplier of structural test on aeronautical elements.

CAD Data management:

CATIA V5 R22 will be used for drawing, 3D model and data management.

Simulation Data and Process management:

SimManager 2014 will be used to trace and monitor simulation process facilitating constitution of certification dossier

Note:

Detailed Quality Assurance Requirements for Supplier as well as Intellectual Property management will be

provided and detailed to the selected Partner(s) by AgustaWestland, following the signature of dedicated NDA (or equivalent commitment), during the partner agreement phase.

5. Abbreviations

AW	AgustaWestland
CDR	Critical Design Review
CS2	Clean Sky 2
DAL	Design Assurance Level
DDP	Declaration of Design and Performance
DMU	Digital Mock Up
DOA	Design Organization Approval
FRC	Fast RotorCraft
IADP	Innovative Aircraft Demonstrator Platform
ITD	Integrated Technology Demonstrator
JU	Joint Undertaking
MoM	Minute of Meeting
MGB	Main Gearbox
NDA	Non Disclosure Agreement
NGCTR	Next Generation Civil TiltRotor
PDR	Preliminary Design Review
PR	Problem Report
SOF	Safety of Flight
SRR	System Requirement Review
TBC	To Be Confirmed
TBD	To Be Defined
TRR	Test Readiness Review
TTL	Technical Task Leader
WAL	Work Area Leader

IV. Design, development and flight qualification of a high speed / high torque novel freewheeling clutch architecture for tiltrotor main drive system

Type of action (RIA or IA)	IA		
Programme Area	FRC (Tilt-Rotor)		
Joint Technical Programme (JTP) Ref.	WP Level 1 – FRC WP1.3		
Indicative Funding Topic Value (in k€)	750 k€		
Duration of the action (in Months)	36 months	Indicative Start Date²¹	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-FRC-01-04	Design, development and flight qualification of a high speed / high torque novel freewheeling clutch architecture for tiltrotor main drive system
Short description (3 lines)	
The objective is to design, develop, manufacture, test and flight qualify a novel type of freewheeling clutch system for high speed / high torque application to be integrated in the drivetrain of a tiltrotor. The main challenges are due to the need of obtaining extreme reliability and safety in a very compact format. The components will be integrated in the demonstrator drivetrain.	

²¹ The start date corresponds to actual start date with all legal documents in place.

1. Background

Within the scope of Clean Sky 2 Fast Rotorcraft (FRC) Innovative Aircraft Demonstrator Platform (IADP) framework, the Next Generation Civil Tiltrotor project (NextGenCTR) is aimed at designing, building and flying a technology demonstrator to validate an innovative tiltrotor concept, the configuration of which will go beyond current architectures of this type of aircraft. In summary, this concept will involve tilting prop-rotors mounted in fixed nacelles at the tips of relatively short wings, consisting of a fixed inboard and a tilting outboard portion next to the nacelle. The tilting portion will move in coordination with the prop-rotors, to minimize rotor downwash impingement in hover and increase efficiency. The demonstration activities of the NextGenCTR IADP aim at validating the proposed architecture, technologies, systems and operational concepts to prove significant improvements with respect to the current state-of-the-art for tiltrotor concepts. The project will also allow developing substantial R&T activities to increase the know-how about tiltrotors and to generate steady, high volume research and innovation activities comparable to that of well proven helicopter platforms.

In addition to the IADP for complex vehicle configurations, the Clean Sky 2 project defines also the so-called Integrated Technology Demonstrators (ITDs) that will accommodate the main relevant technology streams for all air vehicle applications. They allow the maturing of verified and validated technologies from their basic levels to the integration of entire functional systems. Thus the ITDs can cover quite a wide range of technology readiness levels. Further details regarding the Clean Sky 2 Project are described into the Clean Sky 2 Joint Technical Programme (V5).

The Call proposal from applicants for the role of Partner, described in the present document, is part of the NextGenCTR FRC IADP and in particular is managed within the Workpackage 1.3 “Highly Reliable, Safe & Environmentally Friendly Drive System” in accordance with the Clean Sky 2 Joint Technical Programme Rev. 5, paragraph 8.6.8. Aim of this WP is the design, manufacturing and testing at component level of an innovative drive system for the NextGenCTR. The research targets safe and reliable design, low environmental impact, low production and operational costs. In particular, the object of this Call is the design of a novel freewheeling clutch including innovative architecture.

Freewheel is a mechanical device able to disengage the drive shaft from the driven one, in presence of a differential velocity: the power transmission is disabled when the driven shaft rotates faster than the driver. By its nature, a freewheel mechanism acts as an automatic clutch, by means of asymmetric shaped elements (known as *sprag*) whose relative position, as regards to both inner and outer ring, will determine slippage or friction binding configuration of the whole system. As a direct consequence, in case of high torque or high speeds, the freewheel elements are relevantly stressed, respectively in clutched or freewheeled operating condition. The challenge is to design a suitable system, able to meet the functional requirements with a light and compact configuration.

The present document describes the main activities to be performed, the general time scheduling, the expected results and deliverable as well as the general requirements that JU shall consider for the selection of the appropriate Partner(s).

2. Scope of work

The activity within this Call is aimed to design, manufacture and test a flight cleared freewheel clutch for high

torque and high speeds. This system should include an optimized design to meet the ecological challenges and to be environment sustainable, in accordance with the general rules of Clean Sky 2 programme.

The freewheel architecture may include innovative designs and materials and leading edge and trend setting manufacturing processes. Being part of the critical path for the NextGenCTR flight demonstrator development, in case of technical readiness levels (TRL) lower than 4 in 2016, a more conventional solution must be provided and implemented as a back-up.

The main topics to be investigated during the design phase are:

- ❑ Maximization of the transmitted torque versus weight ratio
- ❑ Light and compact design
- ❑ System performances, safety and reliability
- ❑ Maintainability and inspectability
- ❑ Environmental friendly life and production cycle

Tasks		
Ref. No.	Title – Description	Due Date [T0 + mm]
T1	Feasibility Study and Preliminary Design Trade-off across existing technologies. Architecture concept definition and concept of the freewheel system preliminary design. Analytical and/or experimental critical functions proof of concept. Interface drawings, detailed layout design and dedicated work plan definition. Basic manufacturing implications identification	T0+9
T2	Detailed Design and Process Development Technical drawings and production cycles execution. Definition of the optimized manufacturing processes, quality and inspection procedures to guarantee the fit, form and functional requirements fulfillment (ref. SAE Aerospace Standard AS9100C). Manufacturing proof of concept development.	T0+21
T3	Prototype and testing Supply chain and quality assurance assessment for prototype production in a pilot line environment. Manufacturing of an appropriate number of specimens and parts (the exact number of specimens will be discussed and agreed part during the negotiation process with the selected Partner). Test at component or sub-assembly level to guarantee the design requirements fulfillment and support to the full-scale test phase aimed to achieve the flight clearance of the NextGenCTR demonstrator. Engineering cost and industrial capability assessment to enable the production phase start-up.	T0+36

Task Breakdown and Planning

Month	3	6	9	12	15	18	21	24	27	30	33	36
T1: Feasibility Study and Preliminary Design												



T2: Detailed Design and Process Development			
T3: Prototype and testing			

△ CDR

In order to validate the proposed freewheel architecture and mitigate the associated risk, a dedicated test specimen aimed to substitute an already existing helicopter drive system freewheel will be designed and produced (ref. Table 4).

Inner race diameter	[mm]	72.217^{+0.008}_{-0.005}
Outer race diameter	[mm]	91.211^{±0.013}
Min axial length	[mm]	28.93
Basic (Max) torque rating	[Nm]	2300 Nm (3910) Nm

Table 4: Existing design basic data

A dedicated full-scale test performed by AgustaWestland laboratory, is conceived to substantiate the functional requirements of the novel design and to achieve the technology proof of concept.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type	Due Date
T1.D1	System Requirement Review meeting MoM	Document	T0+3
T1.D2	Preliminary Design Review meeting MoM, including: 3D CATIA Model of the items and digital 3D Mock-up - Interface drawings - Detailed layout and study of the proposed system	Document	T0+9
T2.D1	Preliminary test phase review meeting	Document	T0+18
T2.D2	Critical Design Review meeting MoM, including: - Technical drawings (component and assembly level) - Production cycles (component and assembly level) - Structural substantiation of the new design proposals - Acceptance and inspection criteria	Document	T0+21

Deliverables			
Ref. No.	Title - Description	Type	Due Date
T3.D1	Freewheel Prototypes delivered to AW	Production	T0+24
T3.D2	Test Plan Proposal acceptance by AW	Document	T0+20
T3.D3	Test Phase Review meeting MoM	Document	T0+21
T3.D4	Tests Readiness Review meeting MoM	Document	T0+24
T3.D5	Test Report acceptance by AW	Document	T0+33
T3.D6	Freewheel Production Set delivered to AW	Production	T0+36
T4.D7	Flight Clearance Document acceptance by AW	Document	T0+36

Milestones (when appropriate)			
Ref. No.	Title - Description	Type	Due Date
T1.M1	Detail layout and study of the system acceptance by AW	Documents	T0+9
T1.M2	System Requirement Review meeting	Meeting	T0+3
T1.M3	Preliminary Design Review meeting	Meeting	T0+9
T2.M1	Technical drawings acceptance by AW	Documents	T0+20
T2.M2	Production cycles acceptance by AW	Documents	T0+21
T2.M3	Preliminary Test Phase Review meeting	Meeting	T0+18
T2.M4	Critical Design Review meeting	Meeting	T0+21
T3.M1	Prototypes availability	Production	T0+24

Milestones (when appropriate)			
Ref. No.	Title - Description	Type	Due Date
T3.M2	Test Phase Review meeting	Meeting	T0+21
T3.M3	Tests Readiness Review meeting	Meeting	T0+24
T3.M4	Structural / Functional Tests execution	Test	T0+30
T3.M5	Components availability for NextGenCTR test phase	Production	T0+36
T3.M6	Flight clearance approved by AW	Documents	T0+36

NOTE: Deliverables and Milestones listed in the above tables are intended to be part of the technical data exchange between the selected CfP candidate and the Topic Leader (AW), while the contractual milestones and deliverables, and related terms of agreements, between the selected CfP candidate and the JU will be detailed and mutually agreed during the Negotiation Kick-off meeting phase.

4. Special skills, Capabilities, Certification expected from the Applicant(s)

The Applicant(s) (company or consortium) should describe its experience/capacities in the following subjects:

- ❑ Experience in design and sizing of clutch systems
- ❑ Tools for design, including stress analysis. Experience in the aeronautical business sector is preferred (i.e. CATIA v5, NASTRAN or equivalent)
- ❑ Proven capability and experience in manufacturing and testing of clutch system. Experience in aeronautical business sector is preferred
- ❑ Experience with TRL Reviews in research and manufacturing projects. Experience in aeronautical business sector is preferred
- ❑ Experience in integration multidisciplinary teams in concurrent engineering. Experience in aeronautical business sector is preferred
- ❑ Experience in technological research and development for innovative processes
- ❑ Participation in international R&T projects cooperating with industrial partners, institutions, technology centres and universities.
- ❑ Proven experience in collaborating with referenced aeronautical companies Research and Technology programs
- ❑ Capability of evaluating the experimental results versus the technical requirements
- ❑ Capability of evaluating results in accordance to Horizon 2020 environmental and productivity goals following Clean Sky 2 Technology Evaluator rules and procedures.

Manufacturing capability and equipment:

Following list gives an overview of required available equipment but can be extended by Partner(s) approved technologies:

- ❑ Facilities and machines for part roughing and grinding, heat treatment and hard coating, if any;
- ❑ Non destructive inspection capabilities and required equipment (i.e. eddy current, ultrasonic, X-ray, Tomography, magnetic, nital etch, dimensional inspection systems, as required)
The detailed list of equipments required for the proper inspection and quality check of the manufactured components is a function of the technologies used for the production. Thus the quality inspection criteria will be part of the Preliminary Design Review outcomes;
- ❑ Testing facilities (availability of dedicated bench test rigs for functional and structural tests)

Certification (preferred):

- ❑ Design Organization Approval (DOA).
- ❑ Product Organization Approvals (POA).
- ❑ Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004)
- ❑ Qualification as strategic supplier of structural test on aeronautical elements.

CAD Data management:

CATIA V5 R22 will be used for drawing, 3D model and data management.

Note:

Detailed Quality Assurance Requirements for Supplier as well as Intellectual Property management will be provided and detailed to the selected Partner(s) by AgustaWestland, following the signature of dedicated NDA (or equivalent commitment), during the partner agreement phase.

5. Abbreviations

AW	AgustaWestland
CDR	Critical Design Review
CS2	Clean Sky 2
DAL	Design Assurance Level
DDP	Declaration of Design and Performance
DOA	Design Organization Approval
FRC	Fast RotorCraft
IADP	Innovative Aircraft Demonstrator Platform
ITD	Integrated Technology Demonstrator
JU	Joint Undertaking
MoM	Minute of Meeting
NDA	Non Disclosure Agreement
NGCTR	Next Generation Civil TiltRotor
PDR	Preliminary Design Review
PR	Problem Report
SOF	Safety of Flight
SRR	System Requirement Review
TBC	To Be Confirmed
TBD	To Be Defined
TRL	Technical Readiness Level
TRR	Test Readiness Review
TTL	Technical Task Leader
WAL	Work Area Leader

V. Design, development and flight qualification of a novel, integrated high efficiency heat exchanger for tiltrotor transmission system oil cooling

Type of action (RIA or IA)	IA		
Programme Area	FRC (Tilt-Rotor)		
Joint Technical Programme (JTP) Ref.	WP Level 1 – FRC WP1.3		
Indicative Funding Topic Value (in k€)	350 k€		
Duration of the action (in Months)	24 months	Indicative Start Date²²	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-FRC-01-05	Design, development and flight qualification of a novel, integrated high efficiency heat exchanger for tiltrotor transmission system oil cooling
Short description (3 lines)	
The objective is to design, develop, manufacture and test and a novel type of transmission oil heat exchanger fully integrated to tiltrotor drive system. Main challenges are related to the achievement of high compactness while maximizing heat rejection performances and minimizing risk of oil leakage.	

²² The start date corresponds to actual start date with all legal documents in place.

1. Background

Within the scope of Clean Sky 2 Fast Rotorcraft (FRC) Innovative Aircraft Demonstrator Platform (IADP) framework, the Next Generation Civil Tiltrotor project (NextGenCTR) is aimed at designing, building and flying a technology demonstrator to validate an innovative tiltrotor concept, the configuration of which will go beyond current architectures of this type of aircraft. In summary, this concept will involve tilting prop-rotors mounted in fixed nacelles at the tips of relatively short wings, consisting of a fixed inboard and a tilting outboard portion next to the nacelle. The tilting portion will move in coordination with the prop-rotors, to minimize rotor downwash impingement in hover and increase efficiency. The demonstration activities of the NextGenCTR IADP aim at validating the proposed architecture, technologies, systems and operational concepts to prove significant improvements with respect to the current state-of-the-art for tiltrotor concepts. The project will also allow developing substantial R&T activities to increase the know-how about tiltrotors and to generate steady, high volume research and innovation activities comparable to that of well proven helicopter platforms.

In addition to the IADP for complex vehicle configurations, the Clean Sky 2 project defines also the so-called Integrated Technology Demonstrators (ITDs) that will accommodate the main relevant technology streams for all air vehicle applications. They allow the maturing of verified and validated technologies from their basic levels to the integration of entire functional systems. Thus the ITDs can cover quite a wide range of technology readiness levels. Further details regarding the Clean Sky 2 Project are described into the Clean Sky 2 Joint Technical Programme (V5).

The Call proposal from applicants for the role of Partner, described in the present document, is part of the NextGenCTR FRC IADP and in particular is managed within the Workpackage 1.3 “Highly Reliable, Safe & Environmentally Friendly Drive System” in accordance with the Clean Sky 2 Joint Technical Programme Rev. 5, paragraph 8.6.8. Aim of this WP is the design, manufacturing and testing at component level of an innovative drive system for the NextGenCTR. The research targets safe and reliable design, low environmental impact, low production and operational costs. In particular, the object of the Call is the design of a novel, integrated and high efficiency heat exchanger.

Heat exchangers typically used in aerospace applications are plate-fin type. A compact plate-fin heat exchanger is made by a stack of alternating layers of corrugated fins and separating plates (parting sheets) that create a series of finned chambers joined together by means of brazing. Coolant flow crosses in single or multiple passages the fluid carrying the heat produced by the system to be refrigerated.

In particular, thermal management of a rotorcraft transmission system is provided by the lubricant oil flow circulating through a plate fin heat exchanger crossed by the air flow produced by a cooling fan. Due to moderate temperature and pressure of lubricant oil passing through the cooling system, the heat exchanger is typically made in Al-alloy rather than steel.

Aim of this activity is to investigate any better configuration to achieve same heat rejection with lower weight and smaller overall dimensions than a conventional compact plate-fin heat exchanger design. In addition, a better integration to transmission system (without impairing cooler efficiency) is required to reduce risk of oil leakage from weak points (i.e. pressurized weldings subjected to significant vibration forces or flexible hoses) that may be cause for gearbox catastrophic failures in case of total loss of oil.

The present document describes the main activities to be performed, the general time scheduling, the expected results and deliverable as well as the general requirements that JU shall consider for the selection of the appropriate Partner(s).

2. Scope of work

Tasks		
Ref. No.	Title - Description	Due Date
T1	Cooler thermal conceptual design to define cooler matrix configuration, overall dimensions and required air flow at given lubricant oil flow. The outcomes of the conceptual design will be the basis of the integrated architecture layout.	T0 + 3 months
T2	General layout definition and architecture integration based on applicable design constraints (available space, main interfaces, oil/air ports position and size, max allowed weight) and implementation of suitable oil leakage risk mitigation features. Final layout shall be selected by means of a trade-off between solutions developed to maximize thermal efficiency, weight, compactness, safety and manufacturing cost.	T0 + 6 months
T3	Detail design of single components (geometry, selected manufacturing technologies, treatments, tolerancing) to provide drawings valid for tooling design, purchasing of raw material, bought out parts and launch of manufacturing of long lead time items (i.e. castings).	T0 + 9 months
T4	Structural substantiation against pressurization, thermal, inertial and vibration loads. It must be shown by analysis that the stress level under nominal operating condition is within the limit of the materials used for the manufacturing of each part and that there is not any dynamic response of the cooler assembly at the typical forcing frequencies present in the neighbourhood of the cooling system installation.	T0 + 9 months
T5	Manufacturing of prototypic units for early qualification testing. Rapid prototyping techniques may be used to shorten lead time and produce more configurations for comparative testing.	T0 + 18 months
T6	Functional and structural testing to ensure thermal performances at both rated condition and also with different air/oil temperatures, air/oil flow rates (i.e. definition of heat exchanger carpet plot) and structural strength at minimum/maximum temperatures, pressures and accelerations to verify both static (proof and burst pressure test) and fatigue (pressure-cycle test, vibration test) strength.	T0 + 21 months
T7	Qualification to demonstrate compliance against relevant certification requirements.	T0 + 24 months

Cooler performances shall be demonstrated by means of a test specimen with same matrix (fin type, density, thickness and height on both air side and oil) to be used for final application but smaller overall dimensions to be tested on existing rig at AW transmission lab. In particular, dimensional constraints to be considered to design a cross flow type compact heat exchanger are:

- Air flow length: 100 mm (single pass)
- Oil flow length: 220 mm (double pass / with recirculation cup)
- Width: 220 mm

The heat exchanger shall be able to reject at least 50 kW considering the following oil and air flows:

1. Oil:
 - Inlet temperature: 130°C

- Oil flow: 65 l/min
- Pressure drop on oil side: 115 kPa

2. Air:

- Inlet temperature: 54°C
- Air flow: 60 kg/min
- Pressure drop on air side: 55 hPa

Task Breakdown and Planning

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
T1: Cooler Thermal concept. design																								
T2: General layout definition																								
T3: Detail design																								
T4: Structural substantiation																								
T5: Manufacturing																								
T6: Functional & Structural testing																								
T7: Qualification																								

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type	Due Date
T1.D1	System Requirement Review meeting MoM, including: - Performance Analysis - thermal analysis for core matrix sizing considering selected technologies for manufacturing. - Weight Vs Heat Rejection Rate analysis is required at this stage.	Document	T0 + 3 months
T2.D1	Preliminary Design Review meeting MOM, including: - General layout studies for trade-off evaluation of different system configurations. - Comparative test articles may be used to validate different solutions technologies to be used in production configuration. - Design Assessment of proposed configurations against risk of failures resulting in major oil leakage (Safety analysis).	Document	T0 + 6 months
T3.D1 T4.D1	Critical Design Review meeting MOM, including: - Outline drawing for cooler assembly (only for selected cooler configuration). - Stress analysis of cooler assembly in static and fatigue condition + dynamic response analysis. - Innovative technologies / critical manufacturing processes validation.	Document	T0 + 9 months
T5.D1	Prototypes delivered to AW	Production	T0 + 18 months
T6.D1	Development test plan (performances, carpet plot) acceptance by AW	Document	T0 + 12 months
T7.D1	Qualification test plan (static and fatigue strength, environmental condition) acceptance by AW	Document	T0 + 12 months
T7.D2	Development test report (performances, carpet plot) acceptance by AW	Document	T0 + 18 months
T7.D3	Qualification test report (static and fatigue strength, environmental condition) acceptance by AW	Document	T0 +24 months

Milestones (when appropriate)			
Ref. No.	Title - Description	Type	Due Date
T1.M1	Kick-off meeting to present thermal design of the heat exchanger and define relevant interfaces/design constraints.	Meeting	T0 + 1 months
T1.M2	System Requirement Review meeting to present the frozen conceptual design	Meeting	T0 + 3 months
T2.M1	General Layout availability (approved by AW)	Document	T0 + 6 months

Milestones (when appropriate)			
Ref. No.	Title - Description	Type	Due Date
T2.M2	Preliminary Design Review to present layout studies and select production configuration based on analysis and estimated performances data.	Meeting / drawing review	T0 + 6 months
T3.M1 T4.M1	Critical Design Review to review final outline drawing, manufacturing technologies and other critical aspects required to freeze final production configuration for manufacturing.	Meeting / drawing review	T0 + 9 months
T5.M1	Prototypes Availability	Production	T0 + 18 months
T6.M1	Test Readiness Review to review test plans (development, qualification), test fixtures and relevant documentation concerning manufactured items.	Meeting / documents review	T0 + 18 months
T7.M1	Final Wrap Up meeting to review qualification test report issued at the end of testing phase to identify further improvements/iterations to be implemented on the selected solution.	Meeting	T0 + 24 months

NOTE: Deliverables and Milestones listed in the above tables are intended to be part of the technical data exchange between the selected CfP candidate and the Topic Leader (AW), while the contractual milestones and deliverables, and related terms of agreements, between the selected CfP candidate and the JU will be detailed and mutually agreed during the Negotiation Kick-off meeting phase.

4. Special skills, Capabilities, Certification expected from the Applicant(s)

The Applicant(s) (company or consortium) shall describe its experience/capacities in the following subjects:

- ❑ Thermal design of an heat exchanger core matrix considering different layouts/manufacturing technologies using both convential and CFD techniques;
- ❑ Stress analysis using both conventional and FEM techniques for evaluation of static pressurizatiion and inertial forces due to steady accelerations;
- ❑ Dynamic analysis for assesment of stress distribution deriving from vibrations and inertial forces due to shock acceleration;
- ❑ Sand/investment casting technologies knowledge to design and manufacture (or procure) oil headers/collectors;
- ❑ Proven Experience in precision heat exchanger core matrix design and production. Experience in aeronautical business sector is preferred
- ❑ Certified Aerospace quality welding capability and NDI inspection of welding seam;
- ❑ Perofmance testing using different flow rates on both air side / oil side (hdraulic/aeraulic test rig) to simulate different combinations of test conditions);
- ❑ Certified environmental testing capability (low/high temperature, salt fog, vibrations, accelerations, etc.).

Certification (preferred):

- ❑ Design Organization Approval (DOA).
- ❑ Product Organization Approvals (POA).
- ❑ Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004)
- ❑ Qualification as strategic supplier of structural test on aeronautical elements.

CAD Data management:

CATIA V5 R22 will be used for drawing, 3D model and data management.

Note:

Detailed Quality Assurance Requirements for Supplier as well as Intellectual Property management will be provided and detailed to the selected Partner(s) by AgustaWestland, following the signature of dedicated NDA (or equivalent commitment), during the partner agreement phase.

5. Abbreviations

AW AgustaWestland

CDR	Critical Design Review
CS2	Clean Sky 2
DAL	Design Assurance Level
DDP	Declaration of Design and Performance
DOA	Design Organization Approval
FRC	Fast RotorCraft
IADP	Innovative Aircraft Demonstrator Platform
ITD	Integrated Technology Demonstrator
JU	Joint Undertaking
MoM	Minute of Meeting
NDA	Non Disclosure Agreement
NGCTR	Next Generation Civil TiltRotor
PDR	Preliminary Design Review
PR	Problem Report
SOF	Safety of Flight
SRR	System Requirement Review
TBC	To Be Confirmed
TBD	To Be Defined
TRL	Technical Readiness Level
TRR	Test Readiness Review
TTL	Technical Task Leader
WAL	Work Area Leader

VI. Design, development, testing and qualification of a high-reliability integrated fuel gauging and distribution system providing active CG management in a civil tiltrotor

Type of action (RIA or IA)	IA		
Programme Area	FRC (Tilt-Rotor)		
Joint Technical Programme (JTP) Ref.	WP Level 1 – FRC 1.1 and 1.5		
Indicative Funding Topic Value (in k€)	750 k€		
Duration of the action (in Months)	60 months	Indicative Start Date²³	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-FRC-01-06	Design, development, testing and qualification of a high-reliability integrated fuel gauging and distribution system providing active CG management in a civil tiltrotor
Short description (3 lines)	
This document reports the general requirements considered for the selection of an appropriate Partner for design, development, testing and qualification of an integrated fuel gauging and distribution system for the NGCTR.	

²³ The start date corresponds to actual start date with all legal documents in place.



1. Background

In the framework of Clean Sky 2 FRC IADP, the present Call requires Partner(s) (company or consortium) to develop an integrated fuel gauging and distribution system for NGCTR.

2. Scope of work

The NGCTR fuel system shall be designed in such a way that the main system functionalities and performances (storage, distribution, gauging and venting) are guaranteed throughout the whole flight envelope, whilst ensuring adequate safety levels and environment protection.

The fuel shall be delivered to two different engines located at the tip of the wing in a high wing configuration tiltrotor.

Innovative system architecture specifically tailored to NGCTR tanks and structures peculiarity shall be taken into account.

Fuel flow and pressure shall be guaranteed to the engine inlet for the full duration of each flight: this should be accomplished by a fuel system architecture having an estimated rate of failure of 10^{-9} failure/hour. This latter target rate of failure shall be reached by means of a combination of system architecture and system equipment robustness and redundancies, able to accommodate for fuel contaminants, and presence of water and ice. In particular, the Partner shall carry out a trade-off study for a filtration system capable of providing a filtered volume of fuel, which contains no water nor contaminants, from where the fuel is taken and to be delivered to the engine. The system should provide this full fuel filtration of water and contaminants while avoiding/preventing any ice accretion which could jeopardize fuel feed delivery.

In addition, an active control of the fuel distribution and monitoring system shall be investigated and implemented in the design, with the aim of managing the system CoG according to the requests provided by the aircraft FCS to increase efficiency and optimize performance of the tiltrotor.

The Partner shall perform a trade-off study about different control strategies of fuel CoG which should be made by active or passive fuel quantity/flow control methods. The control laws of fuel CoG shall be provided by AW.

Advanced low-power consumption, highly reliable and self compensated (also in temperature) gauging system, integrated with the Fuel CoG management, shall be provided. The Partner shall provide a gauging system design with the aim of:

- minimizing the power injected into fuel tanks to prevent any possible fuel ignition source;
- being intrinsically insensible to EM interference;
- avoiding the electrical energy entering the tanks.

The Fuel Gauging functionality shall be capable of informing the crew about the presence of an unacceptable quantity of water and/or contaminants in fuel. The fuel gauging system shall be capable to directly measure the density of the fuel and correct the fuel quantity provided to the avionics. A low level detector shall be provided as a part of the fuel gauging system.

The partner shall also develop and provide a tool (or provide a trade-off study) which allows the optimization of

the required number of fuel probes by a smart positioning in the fuel tanks.

The system shall include a single point pressure automatic system refuelling, and shall include capability for in-flight (hover and level flight) refuelling.

A study for an in flight fuel dump system (i.e. fuel jettison) shall be carried out.

The system shall be compatible (and shall provide full performance) with common aeronautical fuels and additives such as, but not limited to JET A, JET A1, JET B, JP8, JP8+100, GOST, TS1, AVGAS, etc..., in accordance with the relevant ASTM and NATO CODE standard specification.

In addition, compatibility with Diesel and bio-diesel fuels, and high level of FAME (Fatty Acid Methyl Ester) concentration (target: 100 mg/kg) fuels shall also be considered.

A system modelling and simulation tool shall also be developed for integration in a full-aircraft avionic test bench. The Partner shall provide a complete simulation model to evaluate the fuel system functionalities. The model shall incorporate the following features:

- Parameterization of the key component characteristics
- Capability of mechanical failure simulation
- Capability of electrical failure simulation
- Capability of mission profile following
- Capability to simulate aircraft attitude

Operation using the 270VDC unregulated main power supply should be considered.

A trade off study for the inclusion of an environmentally friendly inerting system shall also be accomplished as part of the design phase.

All the electromechanical equipment shall be designed to have a HUMS capability in order to optimize maintenance actions and failure detections (i.e. smart probes, smart pumps, etc).

Low maintenance effort and easy accessibility for inspections shall also be considered.

All the components developed shall consider a low environmental impact manufacturing processes.

The massive use of non metallic materials for all the components shall be pursued in order to minimize the system weight and reduce the environmental impact.

The system shall be designed to comply with:

- crashworthy requirements (in particular FAA AC29-2C chg4, paragraph AC29.952 shall be taken into account as a guideline);
- ignition prevention requirements (in particular, AC25.981-1B, AC25.981-1C and AC25.981-2 shall be taken into account as guidelines).

The detailed requirements for the system interfaces with the aircraft will be part of dedicated discussions with the selected Partner, following the signature of dedicated NDA or equivalent commitment.

The design, the development and the qualification of the system shall follow the standard procedures for aeronautic equipment.

Tasks		
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Due Date</i> [T0 + mm]
T01	Trade-off study for fuel filtering solution and water elimination	T0 + 06
T02	Trade-off study for fuel system CoG management	T0 + 06
T03	Trade-off study for fuel gauging system technology	T0 + 06
T04	Optimization of Fuel Probe position	T0 + 06
T05	Evaluation of Fuel System general architecture	T0 + 08
T06	Best control laws to CoG management	T0 + 12
T09	Testing Activity	T0 + 40
T10	System model development	T0 + 50
T11	System qualification	T0 + 60

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title – Description	Type	Due Date [T0 + mm]
D01	Trade-off study report for fuel filtering solution and water elimination	REPORT	T0 + 06
D02	Trade-off study report for fuel system CoG management	REPORT	T0 + 06
D03	Trade-off study report for fuel gauging system technology	REPORT	T0 + 06
D04	Fuel Ignition Source Analysis/Assessment	REPORT	T0 + 08
D05	3d models and layout drawing	CATIA FILES	T0 + 12
D06	Qualification program plan (QPP)	REPORT	T0 + 12
D07	Development test plan (DP)	REPORT	T0 + 12
D08	Performance analysis	REPORT	T0 + 12
D09	Reliability and Failure Modes & Effects Analysis (FMEA)	REPORT	T0 + 14
D10	Failure Modes, Effect and Criticality Analysis (FMECA)	REPORT	T0 + 14
Deliverables (continues)			
Ref. No.	Title – Description	Type	Due Date [T0 + mm]
D11	Safety/Hazard Analysis	REPORT	T0 + 14
D12	SW development and quality plan	REPORT	T0 + 14
D13	Control laws	SIMULINK (or similar) FILE	T0 + 14
D14	Interface control drawings	CATIA FILES	T0 + 24
D15	Acceptance Test Procedures (ATP)	REPORT	T0 + 24
D16	EMC Control Plan	REPORT	T0 + 34
D17	EMC Test Plan	REPORT	T0 + 34
D18	Qualification Test Procedures (QTP)	REPORT	T0 + 24
D19	Qualification by Similarity and Analysis (QSAR)	REPORT	T0 + 24
D20	1 st Shipset availability	HARDWARE AVAILABILITY	T0 + 30
D21	Spare shipset availability	HARDWARE AVAILABILITY	T0 + 42
D22	EMC Test Reports	REPORT	T0 + 60
D23	Qualification Test Reports	REPORT	T0 + 60
D24	Instruction for Continued Airworthiness	MANUAL	T0 + 60

Milestones			
Ref. No.	Title - Description	Type	Due Date [T0 + mm]
M01	Kick-off meeting	DESIGN REVIEW	T0
M02	System Concept Review	DESIGN REVIEW	T0 + 06
M03	Preliminary Design Review	DESIGN REVIEW	T0 + 12
M04	Development unit ready to development tests	HARDWARE AVAILABILITY	T0 + 24
M05	Critical Design Review	DESIGN REVIEW	T0 + 24
M07	First Article Inspection	DOCUMENT	T0 + 30
M08	Test Readiness Review	DESIGN REVIEW	T0 + 30
M09	Unit in product configuration delivered to AW for flight tests	HARDWARE AVAILABILITY	T0 + 40
Milestones (continue)			
Ref. No.	Title - Description	Type	Due Date [T0 + mm]
M10	Qualification closure	DOCUMENT & DESIGN REVIEW	T0 + 60

NOTE: Deliverables and Milestones listed in the above tables are intended to be part of the technical data exchange between the selected CfP candidate and the Topic Leader (AW), while the contractual milestones and deliverables, and related terms of agreements, between the selected CfP candidate and the JU will be detailed and mutually agreed during the Negotiation Kick-off meeting phase.

4. Special skills, Capabilities, Certification expected from the Applicant(s)

The Applicant(s) shall own the following pedigree and special skills:

- Compliance to SAE AS9100.
- Experience of aeronautic rules, certification processes and quality requirements.
- Experience in design, validation, manufacturing and environmental/functional qualification of airborne equipments, either fuel systems, avionics systems (embedding complex HW and DAL-A SW) or both, according to RTCA-DO-160, RTCA-DO-178 and RTCA-DO-254 (or other civil or military equivalent standards) for safety critical equipments.
- Familiarity with EMI compatibility issues: capacity to design complex electronic HW in compliance with EMC guidelines, and experience in performing EMC justification analyses and experimental assessments according to RTCA-DO-160, EUROCAE ED-107/ARP-5583, ED-81/ARP-5413 and ED-84/ARP-5412 or equivalent civil or military standards (TBC).
- Experience in research, development and manufacturing in the following technology fields:
 - Conventional fuel system development for aircraft, helicopter and tiltrotors
 - Self-contained, electrically powered, fuel gauging probe
 - High-performance brushless or variable reluctance electrical motors
 - Design of components minimizing ignition hazard in explosive environment
 - Smart actuation and actuator control electronics.
- Well proven engineering and quality procedures capable to produce the necessary documentation and means of compliance to achieve the “Safety of Flight” with the applicable Airworthiness Authorities (FAA, EASA, etc.).
- Design Organization Approval (DOA) desirable.
- Experience in Safety assessment process according to SAE-ARP-4754 and SAE-ARP-4761 standards, willingness to interact closely with WAL safety specialists in order to produce the necessary outputs (safety and reliability reports and fault trees/analyses).
- Shape, component design and structural analysis using CATIA v5 r22, NASTRAN, Matlab or equivalent software.
- Capacity to optimize the HW and SW design, to model mathematically/numerically complex mechatronic systems with suitable simulation tools (Matlab/Simulink, Dymola/Modelica, etc.) and to analyze both simulation and experimental results to ensure that the various required performance goals are met.
- Capacity to repair “in-shop” equipment due to manufacturing deviations.

Detailed Quality Assurance Requirements for Supplier will be provided to the selected Partner(s) following the signature of dedicated NDA or equivalent commitment.

The Partner shall guarantee at least one spare system; consumable availability and technical support even following the full qualification milestone completion.

5. Abbreviations

AW	AgustaWestland
CoG	Center of Gravity
EM	Electromagnetic
EMI	Electromagnetic Interference
EMC	Electromagnetic Compatibility
FCS	Flight Control System
FMEA	Failure Mode and Effect Analysis
HUMS	Health Monitoring and Usage System
HW	Hardware
NGCTR	Next Generation Civil Tiltrotor
NDA	Non Disclosure Agreement
SW	Software
TBC	To Be Confirmed
WAL	Work Area Leader

VII. Light weight, impact resistant, canopy for fast compound rotorcraft

Type of action (RIA or IA)	IA		
Programme Area	FRC (LifeRcraft)		
Joint Technical Programme (JTP) Ref.	FRC2.2 (airframe structure)		
Indicative Funding Topic Value (in k€)	1000 k€		
Duration of the action (in Months)	50 months	Indicative Start Date²⁴	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-FRC-02-09	Light weight, impact resistant, canopy for fast compound rotorcraft
Short description (3 lines)	
A canopy structure has to be developed and manufactured for the Fast Rotorcraft (FRC). It has to comply with the regulations according to CS 29 and has to include features for installed equipment e.g. radar, FLIR, Cable cutter etc. Special care has to put on low aerodynamic drag and weight.	

²⁴ The start date corresponds to actual start date with all legal documents in place.



1. Background

The Fast Rotorcraft Project (FRC) aims at demonstrating that the compound rotorcraft configuration implementing and combining cutting-edge technologies, as from the current Clean Sky Programme, opens up to new mobility roles that neither conventional helicopters nor fixed wing aircraft can currently cover in a sustainable way, for both the operators and the industry.

The project will ultimately substantiate the possibility to combine in an advanced rotorcraft the high cruise speed, low fuel consumption and gas emission, low community noise impact, and productivity for operators. A large scale flightworthy demonstrator embodying the new European compound rotorcraft architecture will be designed, integrated and flight tested.

In addition to the complex vehicle configurations, Integrated Technology Demonstrators (ITDs) will accommodate the main relevant technology streams for all air vehicle applications. They allow the maturing of verified and validated technologies from their basic levels to the integration of entire functional systems. They have the ability to cover quite a wide range of technology readiness levels.

2. Scope of work

The subject of this Call for Partner is to include all activities needed for developing and manufacturing the Canopy structure as part of the IADP FRC for further application and use in the High Speed Rotorcraft LifeRCraft. Therefore activities such as engineering activities, manufacturing and test are to be performed in this call. This has to be performed in close cooperation with the TM and other core partners and partners responsible for e.g. Canopy doors, Windscreens, Main Fuselage etc.

In addition to the technical activities the relevant management activities have to be performed also.

Tasks		
Ref. No.	Title - Description	Due Date
T1	Development, layout, design and certification of the Canopy for a High Speed H/C. (Structural architecture and loft delivered by TM) Features to be included: • Minimum impact on overall drag (by TM) • Light weight design, partly hollow structure (max. weight < 60 kg) • Provisions for window attachment • Provisions for Door attachment and sealing • Optimized for Pilot's view capability • Structural provisions for equipment and ECS • Radar-ray transparent nose fairing • Maintenance openings • Provisions for extendable/retractable equipment • EMC/bonding and direct lightning effects • Bird strike The development has to be done in close cooperation with the Topic Manager and other core partners and partners contributing to Canopy interfaces. The task includes all relevant toolings.	T + 6
T2	Manufacturing of the Canopy	T + 20
T3	Acceptance testing of the Canopy in order to demonstrate the required characteristics	T + 21
T4	Delivery of flightworthy canopy	T + 22
T5	Start support to final assembly	T + 22
T6	Provide Contribution to obtain permit to flight documentation for the Canopy (final contribution)	T + 24
T7	Contributing to flight test campaign if needed, cost are to be considered by partner as risk mitigation	T + 50

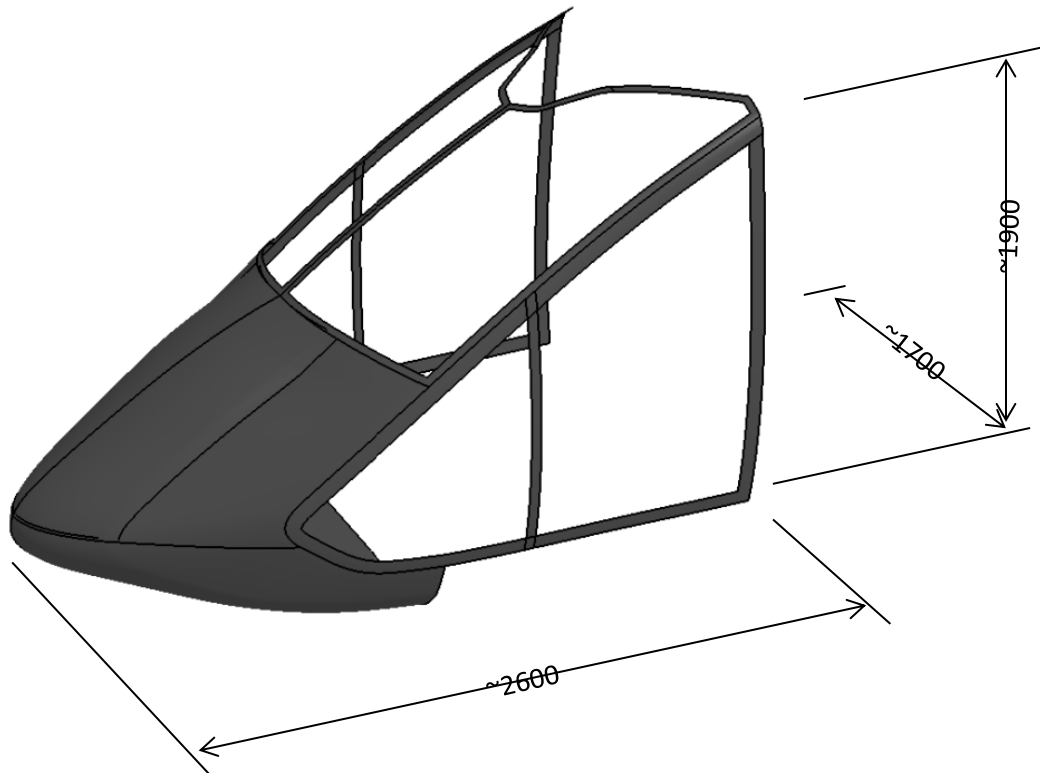
General remarks:

- The architecture of the Canopy will be done in close cooperation with the Topic Manager.
- The development of the Canopy (shape, dimensions, interfaces, etc) has to be done in close cooperation with the Topic Manager.
- Minimum impact on drag and minimum weight are the main conditions. The partner will demonstrate to the topic manager that design is done in accordance with the best compromise in term of weight, cost (for serial production part) and drag.
- The door-frames must be designed in close cooperation with the partner responsible for the doors.
- The window frames must be designed in close cooperation with the partner responsible for the windows.
- The substantiation documentations have to be done according the requirements of the Topic Manager.

A harmonization process of the terms of conditions will take place at start of the project (e.g. tools/methods to be used).

- Certification basis is CS29

Sketches & Dimensions



Canopy (draft)

Final dimension will be defined during the negotiation phase with the partner.

Functional Characteristics

The Canopy maintains the external shape of the cockpit and carries the attachments for the pilots doors, transparencies and other equipment e.g. radar, antennas, etc. The Canopy window post dimensions have to provide the best field of view through windshields and windows for all flight conditions.

Note: the transparency will be provided by another partner selected during the Call nb1.

Maintenance openings and fairings must allow easy and quick access. Forward looking structural elements must be bird strike prove.

Due to the assembly concept, the canopy has to be designed in a way that allows a late installation in the final assembly line

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
<i>Ref. No.</i>	<i>Title – Description</i>	<i>Type</i>	<i>Due Date</i>
D 1	Concept for Canopy (material, structure, etc.)	Doc	T+6
D 2	Detailed drawings	Doc	T+16
D 3	Canopy (not-flightworthy hardware) incl. maintenance doors, fairings for mock up	HW	T+24
D 4	Canopy (flightworthy hardware) incl. maintenance doors, fairings for FRC demonstrator	HW	T+22
D 5	Test and “Permit to Fly” documentation	Doc	T+32
D 6	Support to Flight Test Campaign	-	T+41

Milestones (when appropriate)			
<i>Ref. No.</i>	<i>Title – Description</i>	<i>Type</i>	<i>Due Date</i>
M 1	PDR	MS	T+6
M 2	CDR	MS	T+18
M 3	Flight test survey	MS	T+50

4. Special skills, Capabilities, Certification expected from the Applicant(s)

The Topic Manager is the responsible in front of the airworthiness agency, and it is therefore mandatory that the Topic Manager will be supported by the Partner with respect to all certification related activities in relation with the Canopy. Therefore the Partner has to provide all documentation necessary to achieve "Permit to Fly" and take action allowing this goal to be reached:

- Providing material data which are required to achieve a "Permit to Fly";
- Using material, processes, tools, calculation tools etc. which are commonly accepted in the aeronautic industry and certification authorities;
- Facilitating harmonization of calculation processes/tools with the Topic Manager;
- Acting interactive with the Topic Manager at any state of work;
- Giving access to the production and test sites;
- Performing the updates of documentation in case of in-sufficient documentation for authorities;
- Checking TRL level 4 is reached for each system/technology upon project start (Q2 2016). Should this condition not be met, the Partner has to provide a mitigation plan enabling to reach the target of TRL 6 at the end of demonstration.

Weight:

The target is obtained the lowest weight as possible for the proposed component compliant with technical requirements and compatible with a serial aeronautical production.

The applicant(s) shall provide an estimated maximum weight of its proposed component. This value will be updated before T0 regarding the design data available at this time, the difference with the weight provided with the offer shall be substantiated and the new weight figure will have to be agreed with the Topic Manager.

For the PDR, the Partner shall a detailed weight breakdown of the component in accordance with the technology, the technical requirement and the interfaces agreed with the leader. The difference with the weight agreed at T0 will be substantiated and submitted to the agreement of the Topic Manager.

For the CDR, the Partner shall provide an update of the weight breakdown with a substantiation of the difference with PDR version. If an update of the overall weight is necessary, it will be submitted to the agreement of the Topic Manager.

The components for the flying demo will be delivered with a weight record sheet, deviation with the maximum weight agreed during CDR will be substantiated.

At the end of the contract, the Partner shall provide a weight estimation of the component for a production part in accordance with the lessons learned during the development.

Recurring cost estimation:

The target is to obtain the optimum between the level of performances of the fast rotorcraft and the cost of the potential product.

For the PDR, the Partner will provide an estimation of the recurring cost of the component on the basis of the assumptions given by the Topic Manager. An up-date will be provided for CDR and at the end of the demonstration phase.

Data management:

The Topic Manager will use the following tools for drawing and data management:

- CATIA V5 R21
- VPM
- Windchill

The Partner will provide interface drawings and 3D model for digital mock-up in CATIA V5 R21. The data necessary for configuration management have to be provided in a format compatible with VPM and Windchill tool.

Eco-design

Capacity of performing Life Cycle Analysis (LCA) to define environmental impact of technologies (energy, VOC, waste, etc) is required from the Partner.

This approach will be integrated during design & manufacturing phases. The Topic Manager will be able support LCA approach (Methodologies training or pilot cases).

Capacity to monitor and decrease the use of hazardous substances regarding REACH regulation

Special Skills

Abbreviations: (M) for Mandatory; (A) for Appreciated.

- Experience in design and manufacturing of structures in non-conventional and conventional composite materials (thermoset and thermoplastic plus high temperature systems) and innovative metallic components. (M)
- Design, analysis and configuration management tools of the aeronautical industry (i.e. CATIA v5 release 21, NASTRAN, VPM, Windchill, ...) (M)
- Competence in management of complex projects of research and manufacturing technologies. (M)
- Experience with TRL Reviews or equivalent technology readiness assessment techniques in research and manufacturing projects for aeronautical industry. (M)
- Proven experience in collaborating with reference aeronautical companies with industrial air vehicle developments with “in – flight” components experience. (M)
- Capacity to support documentation and means of compliance to achieve experimental prototype “Permit to Fly” with Airworthiness Authorities (i.e. EASA, FAA and any others which may apply). (M)
- Capacity to specify material and structural tests along the design and manufacturing phases of aeronautical components, including: material screening, panel type tests and instrumentation. (M)
- Capacity to perform structural and functional tests of aeronautical components: test preparation and analysis of results (M)
- Capacity to repair “in-shop” components due to manufacturing deviations. (M)
- Capacity of performing Life Cycle Analysis (LCA) and Life Cycle Cost Analysis (LCCA) of materials and structures. (A)
- Capacity of evaluating design solutions and results along the project with respect to Eco-design rules and requirements. (A)
- Design Organization Approval (DOA). (M)
- Product Organization Approvals (POA). (M)
- Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004)
- Qualification as Material and Ground Testing Laboratory of reference aeronautical companies (i.e. ISO 17025 and Nadcap). (M)
- Technologies for composite manufacturing with OoA processes: e.g. RTM, Infusion, SQRTM Thermoforming, Roll-forming (M)
- Mechanical processes, in both composite material and metallic. Hybrid joints (CFRP + Metal)

- Manual composite manufacturing: hand lay-up (M)
- Tooling design and manufacturing for composite components. (M)
- Advanced Non Destructive Inspection (NDI) and components inspection to support new processes in the frame of an experimental Permit to Fly objective. (M)

Material and Processes

In order to reach the main goals of the project two major aspects have to be considered for materials and processes, namely: maturity and safety for the project.

Because of the ambitious plan to develop a flying prototype in a short time frame, the manufacturing technology of the partner must be on a high maturity level (TRL4) in order to be able to safely reach the required technology readiness for the flying demonstrator.

To secure this condition, the core partner will have to demonstrate the technology readiness for his proposed materials and process and manufacturing technology with a TRL review, to be held together with the Topic Manager.

The TRL review must be held within one year after beginning of the project and must confirm a maturity of TRL5 or at least TRL4 if a solid action plan to reach TRL5 within the scope of one further year and finally meet the TRL target for the demonstrator is validated and accepted by the Topic Manager. Furthermore, since the schedule of the project and the budgetary framework don't allow for larger unanticipated changes in the middle of the project, it is required that at the start of activities the partner demonstrates his capability to develop and manufacture the required items with a baseline technology (which can be e.g. Prepreg, RTM or equivalent) which will be a back-up solution if the new technology to be introduced proves to be too challenging.

This back-up plan, which shall secure the meeting of the project goals shall also be agreed between TM and the Partner within half a year after start of the activities and approved by the JU.

Furthermore the M&P activities shall support the safe inclusion of the partner technology into the complete H/C.

Certification:

- Design Organization Approval (DOA).
- Product Organization Approvals (POA).
- Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004)
- Qualification as Material and Ground Testing Laboratory of reference aeronautical companies (i.e. ISO 17025 and Nadcap).
- Qualification as strategic supplier of structural test on aeronautical elements.

VIII. Multipurpose test rig for transmission gearboxes

Type of action (RIA or IA)	IA		
Programme Area	FRC (LifeRcraft)		
Joint Technical Programme (JTP) Ref.	WP Level 1 – FRC2.6		
Indicative Funding Topic Value (in k€)	800 k€		
Duration of the action (in Months)	44 months (20 w/o support phase)	Indicative Start Date²⁶	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-FRC-02-10	Multipurpose test rig for transmission gearboxes
Short description (3 lines)	
The aim of this Call for Partners is to design, manufacture, test and support the adaptation of the test rig used to develop the Drive System for the Compound Rotorcraft Demonstrator in the frame of IADP FRC.	

²⁶ The start date corresponds to actual start date with all legal documents in place.

1. Background

The Topic Manager has a multipurpose back-to-back test rig which has to be adapted to the innovative architecture of a fast compound rotorcraft drive system.

Those test rig adaptation modules should include an optimized design to meet the ecological challenges and to be sustainable for environment and industry.

The test rig adaptation modules should include an innovative design, trend setting manufacturing processes and innovative materials. However, if the TRL of each innovation is lower than 4 in 2016 and if it is risky for the program, a conventional solution must be provided and might be implemented as a back-up.

The test rig adaptation modules are composed by the following subsystems:

- Main module which simulates the twin engine power feeding
- Two lateral modules which simulate the lateral rotor gearboxes power consumption
- Main Gearbox installation platform.

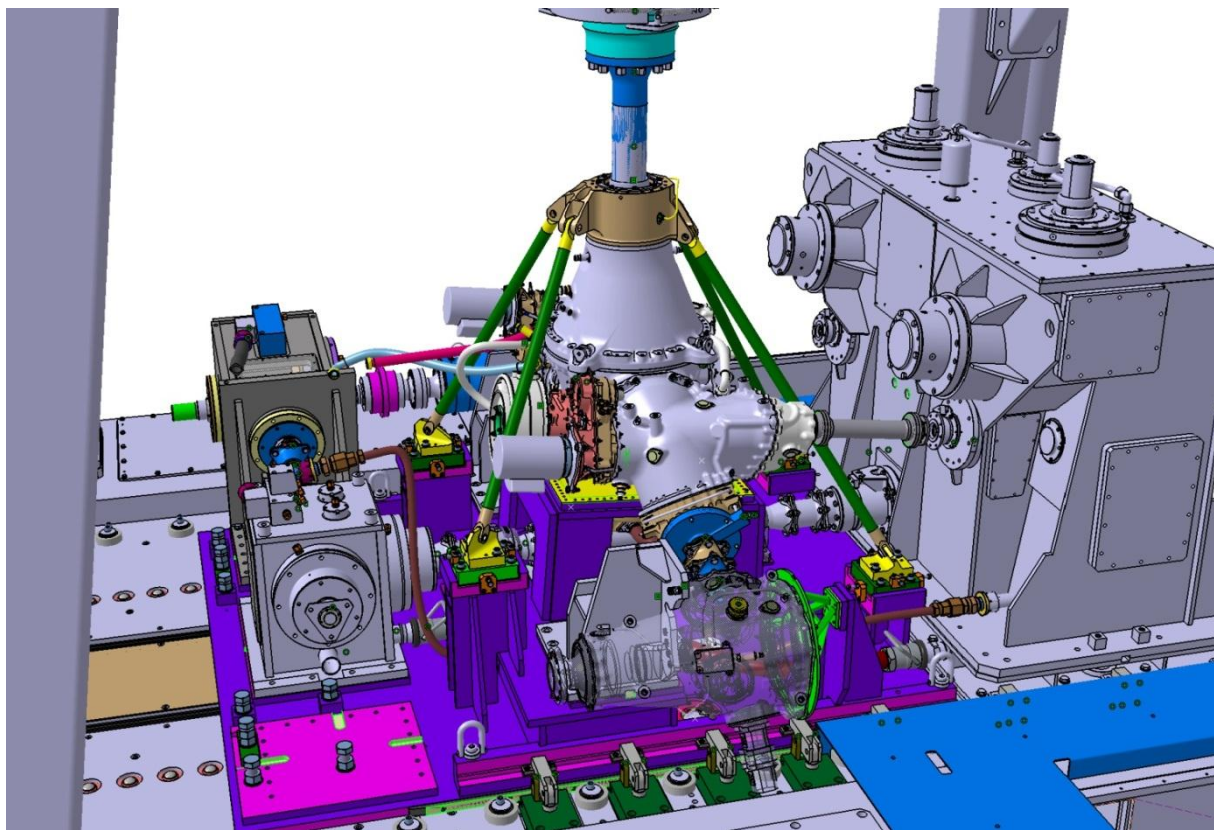


Illustration of test rig module adaptation for X3 demonstrator.

The test rig itself including power generation and control system is out of the scope of this CfP.

An idea for an innovative solution permitting to test at the same time the 2 lateral outputs would be studied

2. Scope of work

Tasks		
Ref. No.	Title - Description	Due Date
2.6.7.1	Design (Study and Detail drawings)	T ₀ +3
2.6.7.2	Manufacturing, assemble and control	T ₀ +9
2.6.7.3	Delivery, adaptation on the test rig and participate to validation tests	T ₀ +20
2.6.7.4	<i>Support/maintenance during demonstration tests (as needed)</i>	T ₀ +44

Task 2.6.7.1: Study and detail design

Starting from a specification provided by Airbus Helicopters, propose a design solution validated by Airbus Helicopters at the PDR. Provide a 3D mock-up of the test rig adaptation. After PDR milestone produce all detail design studies and deliver all detail drawings related to the test rig adaptation modules.

Task 2.6.7.2: Manufacturing, assemble and control

Manufacture, assemble and control in accordance to mechanical standards the adaptation modules for the test rig.

Task 2.6.7.3: Delivery, adaptation on the test rig and participate to validation tests

Deliver, adapt on the test rig and take part in the test validation.

Task 2.6.7.4: Support and maintenance during test campaign

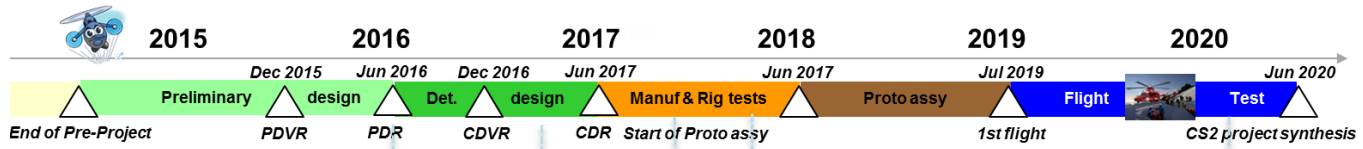
Support and all maintenance activities on the test rig adaptation modules until the end of the development test campaign of the LifeRcraft main gearbox.

3. Major deliverables/ Milestones and schedule (estimate)

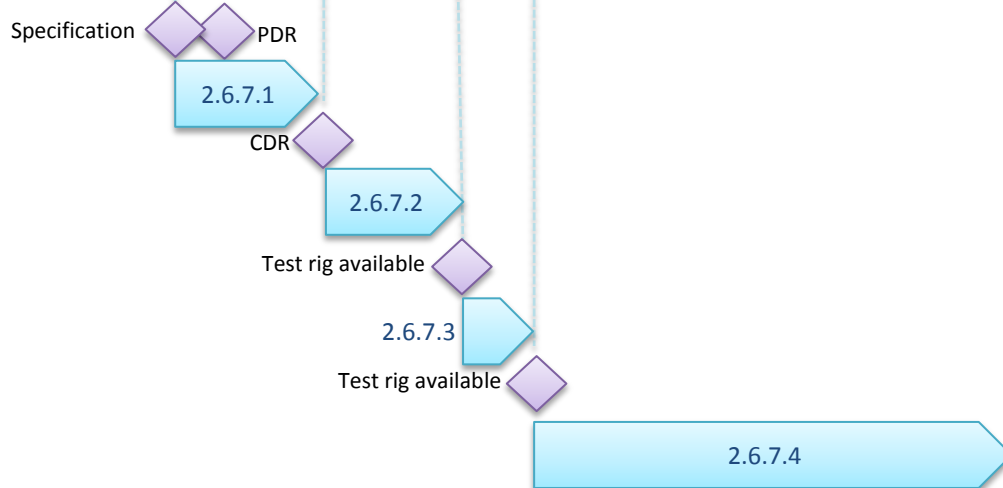
Deliverables			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
D1	Digital mock up	3D	T ₀ +2
D2	Study drawings and definition documents	Drawings Report	T ₀ +3
D3	Detail drawings	Drawings	T ₀ +9
D4	Test rig adaptation hardware	Hardware	T ₀ +17
D5	Quality documentation	Document	T ₀ +17
D6	Test validation report	Report	T ₀ +20

Milestones (when appropriate)			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
M1	Specification provided by Topic Manager	Document	T ₀
M2	Preliminary design review	Milestone	T ₀ +3
M3	Critical design review	Milestone	T ₀ +9
M4	Delivery of hardware and quality control approval document	Delivery	T ₀ +17
M5	Test rig available	Milestone	T ₀ +20

For information overall demonstrator schedule:



Schedule for Multipurpose test rig for transmission gearboxes



4. Special skills, Capabilities, Certification expected from the Applicant(s)

The above mentioned requirements will be fixed in more details during the partner agreement phase. This will also include the IP-process.

Special Skills

The applicant shall describe its experience/capacities in the following subjects:

- Experience in design and sizing of test rig gearboxes.
- Tools for design and stress analysis in the mechanical industry (i.e. CATIA v5 release 21, SAMCEF etc...)
- Capacity and experience in manufacturing parts for drive system (gears, housings, shafts etc...)
- Experience in specifying equipment and following suppliers for gearboxes (bearings, free wheels, sensors etc...), housings, shafts etc...
- Capacity and experience to assemble gearboxes.
- Capacity and experience to test, to develop and to provide support to gearboxes tests
- Tests definition and preparation: stress and strain predictions, deflexion prediction and instrumentation definition
- Analysis of test results
- Capacity of evaluating the results versus the technical proposals from the beginning of the project till the end of it ;
- Capacity to monitor and decrease the use of hazardous substances e.g. compliance with REACH regulation;
- Competence in management of complex projects of drive system development.
- Capacity of providing large mechanical components within industrial quality standards.

Certification:

- Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004)

IX. Design and Realization of equipped engine compartments for a fast compound rotorcraft

Type of action (RIA or IA)	IA		
Programme Area	FRC (LifeRCraft)		
Joint Technical Programme (JTP) Ref.	WP 2.7 Power Plant		
Indicative Funding Topic Value (in k€)	1250 k€		
Duration of the action (in Months)	42 months	Indicative Start Date²⁷	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-FRC-02-11	Design and Realization of equipped engine compartments for a fast compound rotorcraft
Short description (3 lines)	
The scope of this WP includes firewalls, cowlings, engine air inlet systems, engine bay ventilation and halon-free fire extinguishing system	

²⁷ The start date corresponds to actual start date with all legal documents in place.



1. Background

The final goal of the “Low Impact, Fast & Efficient RotorCraft (LifeRCraft)” demonstration program is to mature the compound rotorcraft configuration and pave the way for the development of future products fulfilling expectations in terms of door-to-door mobility, protection of the environment and citizens’ wellbeing better than conventional helicopters.

To achieve the expected performances of the aircraft, a low drag and low penalty design has to be considered. As in any conventional helicopter, the engines are installed in the upper deck ; mass air flow provided thanks to the air intake and engine hot gases exhausted through the ejector. In addition to the optimized definition of such components, it is of major importance to minimize the weight penalty and the recurring cost. The present Call for Proposals is devoted to the development and the manufacturing of the main elements part of the engine compartment : Upper Cowlings, Air Intakes and Ejectors

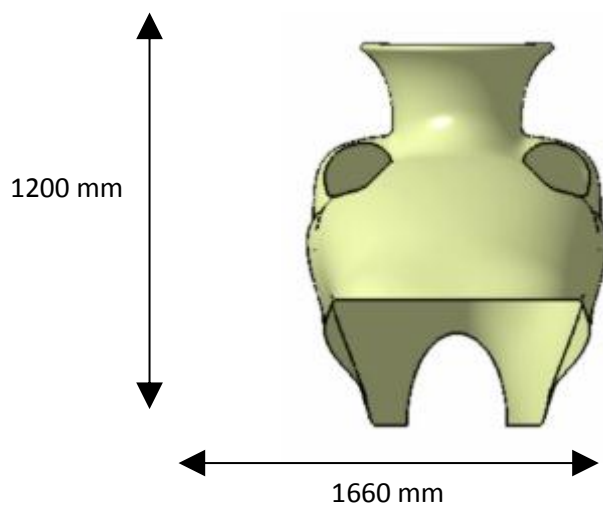
2. Scope of work

The aim of this Call for Proposals is to develop and manufacture the main elements constituting the engine compartments of the High Speed Rotorcraft (Upper Cowlings, Air Intake, Ejector ...). Activities of project management, engineering, manufacturing and tests have then to be performed by the Partner.

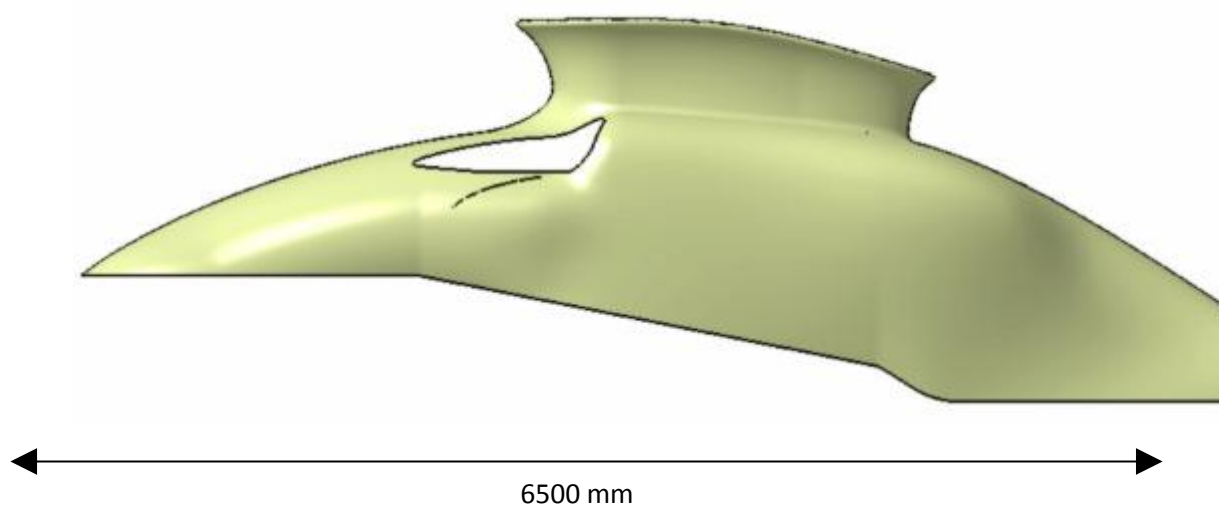
Tasks		
Ref. No.	Title – Description	Due Date
Task 1.0	Inputs Delivery by the Topic Manager	T0
Task 1.1	General Design and Detailed Design of Upper Cowlings for the LifeRCraft Demonstrator	T0+12
Task 1.2	General Design and Detailed design of the Air Intake and Ventilation ducts for the LifeRCraft Demonstrator	T0+12
Task 1.3	General Design and Detailed Design and Flightworthiness substantiation of the ejector for the LifeRCraft Demonstrator	T0+12
Task 1.4	Manufacturing and quality insurance of Upper Cowlings	T0+18
Task 1.5	Manufacturing and quality insurance of Air Intake & ventilation ducts	T0+18
Task 1.6	Manufacturing and quality insurance of Ejector	T0+18
Task 1.7	Airworthiness and compliance substantiation of the Upper Cowlings including Tests	T0+19
Task 1.8	Airworthiness and compliance substantiation of the Air Intake & ventilation ducts including Tests	T0+19
Task 1.9	Airworthiness and compliance substantiation of the Ejector including Tests	T0+19

General remarks:

- Constitutive elements of the upper deck have to be designed, with the target to fulfil all qualification requirements according to CS29 and Special Conditions, if applicable. This includes a full workable cowlings including heat protection system. The partner has to provide substantiation in order to get with the demo manufactured part a demonstrator flight clearance (the full certification compliance substantiation is not required for the demo): it should include description of the design and stress
- The substantiation documentations have to be done according the requirements of the Topic Manager. A harmonization process of the terms of conditions will take place at start of the project (e.g. tools to be used).
- Rough dimension of the upper cowlings are described in the following drawings:

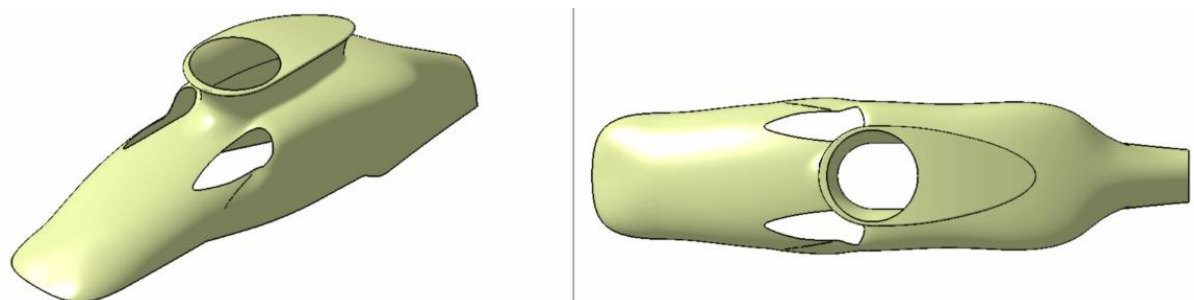


Upper Cowlings : Front View Example



Upper Cowlings : Side View Example : closed

These dimension are a preliminary information, final data will be given at T0.



Upper Cowlings : Global aspect

Task 1.0: Inputs Delivery by the Topic Manager

The Topic Manager will provide to the Partner the following information:

- CAD model files of the A/C (CATIA files) including duct internal geometry and space allocation,
- Structural loads and thermal conditions,
- Functional Specification.

Task 1.1: General Design and Detailed Design of Upper Cowlings for the LifeRCraft Demonstrator

With the preliminary Design, Specification & Requirements provided by the Topic Manager as inputs, the Core Partner is asked to realize the detailed design and detailed definition of the upper cowlings of the aircraft. Such Design must pay peculiar attention on :

- Weight : Light weight design
- Cost : Low recurring cost
- Shape : High shape fidelity (low deviation, low surface waviness, maximum flushness between parts and controlled step and gap) with respect to the loft lines provided by the Topic Manager

This task must also take into account several considerations, such as :

- Computational Structural Mechanics (CSM) calculations to ensure compliance with specified structural loads and temperature
- Easy and fast assembly, installation & removal in accordance to Design Specification
- Improved maintenance & inspections capability in accordance to Design Specification
- Reliable and improved Opening and Locking devices

This task has to be performed in close cooperation with the Topic Manager.

Task 1.2: General Design and Detailed design of the Air Intake and Ventilation ducts for the LifeRCraft Demonstrator

With the preliminary Design, Specification & Requirements provided by the Topic Manager as inputs, the Core Partner is asked to realize the design and detailed definition of the Air Intake and Ventilation ducts (ventilation for equipments) of the aircraft. Such Design must pay peculiar attention on :

- Weight : Light weight design
- Cost : Low recurring cost
- Shape : High shape fidelity (low deviation, low surface waviness, maximum flushness between parts and controlled step and gap) with respect to the loft lines and the other design requirements (quality of surface, gap requirement between ducts, thermal conductivity of the wall, protection screen...) provided by the Topic Manager

This task must also take into account several considerations, such as :

- Computational Structural Mechanics (CSM) calculations to ensure compliance with specified structural loads and temperature
- Easy and fast assembly, installation & removal in accordance to Design Specification
- Improved maintenance & inspections capability in accordance to Design Specification

Optional: Computational Flow Dynamic calculations to ensure compliance with specified air flow requirements

This task has to be performed in close cooperation with the Topic Manager.

Task 1.3: General Design and Detailed Design of the ejector for the LifeRCraft Demonstrator

With the preliminary Design, Specification & Requirements provided by the Topic Manager as inputs, the Core Partner is asked to realize the design and detailed definition of the engine ejector of the aircraft. Such Design must pay peculiar attention on :

- Weight : Light weight design
- Cost : Low recurring cost
- Shape : High shape fidelity (low deviation, low surface waviness, maximum flushness between parts and controlled step and gap) with respect to the loft lines provided by the Topic Manager

This task must also take into account several considerations, such as :

- Computational Structural Mechanics (CSM) calculations to ensure compliance with specified structural loads and temperature
- Thermo-mechanic analysis to ensure compliance with specified requirements
- Easy and fast assembly, installation & removal in accordance to Design Specification
- Improved maintenance & inspections capability in accordance to Design Specification

This task has to be performed in close cooperation with the Topic Manager.

Task 1.4: Manufacturing and quality insurance of Upper Cowlings

The Core Partner has to manufacture the upper cowlings with a proven maturity technology in order to be able to safely reach the required technology readiness for the flying demonstrator. The upper cowlings could be made of several interchangeable parts. The parts have to be delivered with the all documentation necessary to prove compliance with the design within the specified tolerance margins.

Task 1.5: Manufacturing and quality insurance of Air Intake & ventilation ducts

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The Core Partner has to manufacture the Air Intake & ventilation ducts with a proven maturity technology in order to be able to safely reach the required technology readiness for the flying demonstrator. Special attention has to be paid on steps and gaps due to production scatters. The parts have to be delivered with the all documentation necessary to prove compliance with the design within the specified tolerance margins.

Task 1.6: Manufacturing and quality insurance of Ejectors

The Core Partner has to manufacture the ejector with a proven maturity technology in order to be able to safely reach the required technology readiness for the flying demonstrator. The parts have to be delivered with the all documentation necessary to prove compliance with the design within the specified tolerance margins.

Task 1.7: Airworthiness and compliance substantiation of the Upper Cowlings

Manufactured parts must meet airworthiness criteria as needed by the Topic Manager to substantiate the flight demonstrator airworthiness according to Permit to Fly requirements. Particularly, upper cowlings have to be substantiated as « fire-proof ». They must also meet acceptance criteria specified in the Topic Leader functional specification. Flightworthiness and functionality could be demonstrated through dedicated tests (test on specimens or sample parts, validation of steps and gaps due to production scatters, Scan 3D validation, First Article Inspection, etc)

Task 1.8: Airworthiness and compliance substantiation of the Air Intake & ventilation ducts

Manufactured parts must meet airworthiness criteria as needed by the Topic Manager to substantiate the flight demonstrator airworthiness according to Permit to Fly requirements. Particularly, air intakes have to be substantiated as « fire-proof ». They must also meet acceptance criteria specified in the Topic Leader functional specification. Flightworthiness and functionality could be demonstrated through dedicated tests (test on specimens or sample parts, validation of steps and gaps due to production scatters, Scan 3D validation, First Article Inspection ...)

Task 1.9: Airworthiness and compliance substantiation of the Ejector

Manufactured parts must meet airworthiness criteria as needed by the Topic Manager to substantiate the flight demonstrator airworthiness according to Permit to Fly requirements. Particularly, ejectors have to be substantiated as « fire-proof ». They must also meet acceptance criteria specified in the Topic Leader functional specification. Flightworthiness and functionality could be demonstrated through dedicated tests (test on specimens or sample parts, validation of steps and gaps due to production scatters, Scan 3D validation, First Article Inspection ...)

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
L1.1	Concept for Upper Cowlings (material, structure, locking mechanism, modularity ...)	DOC	T0+6
L1.2	Concept for Air Intake and Ventilation Ducts	DOC	T0+6
L1.3	Concept for ejectors (material, structure ...)	DOC	T0+6
L2.1	Detailed Drawings for Upper Cowlings, Air Intakes, Ventilation Ducts and Ejectors	DOC	T0+12
L3.1	Upper Cowlings for Mock-up/tests	HW	T0+16
L3.2	Air Intake and Ventilation Ducts for Mock-up/tests	HW	T0+16
L3.3	Ejector for Mock-up/tests	HW	T0+16
L4.1	Upper Cowlings for Prototype and Flight Tests	HW	T0+24
L4.2	Air Intake and Ventilation Ducts for Prototype and Flight Tests	HW	T0+24
L4.3	Ejector for Prototype and Flight Tests	HW	T0+24
L5.1	Report about contribution to flight test	DOC	T0+42

Milestones (when appropriate)			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
M1	Preliminary Design Review	MS	T0+6
M2	Critical Design Review	MS	T0+12
M3	Acceptance Review	MS	T0+16
M4	Flight Readiness Review	MS	T0+24
M5	First flight test campaign completed with Partner support	MS	T0+42

4. Special skills, Capabilities, Certification expected from the Applicant(s)

The Topic Manager is the responsible in front of the airworthiness agency, and it is therefore mandatory for the Partner to support the Topic Manager with respect to all certification related activities in relation with the upper cowlings, air intake (and ventilation ducts), ejector and engine firewall. Therefore the Partner has to provide all documentation necessary to achieve “Permit to Fly” and take action allowing this goal to be reached:

- Providing material data which are required to achieve a “Permit to Fly”;
- Using material, processes, tools, calculation tools etc. which are commonly accepted in the aeronautic industry and certification authorities;
- Facilitating harmonization of calculation processes/tools with the Topic Manager;
- Acting interactive with the Topic Manager at any state of work;
- Giving access to the production and test sites;
- Performing the updates of documentation in case of in-sufficient documentation for authorities;
- Checking TRL level 4 is reached for each system/technology upon project start (Q2 2016). Should this condition not be met, the Partner has to provide a mitigation plan enabling to reach the target of TRL 6 at the end of demonstration.

Special Skills

The Core Partner should have significant experience in design, manufacturing and testing of metallic and composite airframes.

- Design, analysis and configuration management tools of the aeronautical industry (i.e. CATIA v5 release 21, NASTRAN, VPM, Windchill).
- Competence in management of complex projects of research and manufacturing technologies.
- Experience with TRL Reviews or equivalent technology readiness assessment techniques in research and manufacturing projects for aeronautical industry.
- Proven experience in collaborating with reference aeronautical companies with industrial air vehicle developments with “in – flight” components experience.
- Capacity to support documentation and means of compliance to achieve experimental prototype “Permit to Fly” with Airworthiness Authorities (i.e. EASA, FAA and any others which may apply).
- Capacity to specify material and structural tests along the design and manufacturing phases of aeronautical components, including advanced heat protection technology
- Capacity to perform structural and functional tests of aeronautical components: test preparation and analysis of results.
- Capacity to repair/rework “in-shop” components due to manufacturing deviations.
- Capacity of performing Life Cycle Analysis (LCA) and Life Cycle Cost Analysis (LCCA) of materials and structures.
- Capacity of evaluating design solutions and results along the project with respect to Eco-design rules and requirements.
 - Design Organization Approval (DOA).
 - Product Organization Approvals (POA).
 - Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004)
- Qualification as Material and Ground Testing Laboratory of reference aeronautical companies (i.e. ISO

17025 and Nadcap).

- Technologies for metallic and composite material manufacturing.
- Mechanical processes, regarding assembly of upper cowlings, air intakes, ejector and firewall on the aircraft upper deck.

Material and Processes

In order to reach the main goals of the project two major aspects have to be considered for materials and processes, namely: maturity and safety for the project. Because of the ambitious plan to develop a flying prototype in a short time frame, the manufacturing technology of the partner must be on a high maturity level (TRL4) in order to be able to safely reach the required technology readiness for the flying demonstrator. To secure this condition, the Partner will have to demonstrate the technology readiness for his proposed materials and process and manufacturing technology with a TRL review, to be held together with Topic Manager.

Furthermore, since the schedule of the project and the budgetary framework don't allow for larger unanticipated changes during the project, it is required that at the start of activities the partner demonstrates his capability to develop and manufacture the required items with a baseline technology which will be a back-up solution in case the new technology to be introduced proves to be overly challenging.

This back-up plan, which shall secure the meeting of the project goals, shall also be agreed between the Topic Manager and the Partner within half a year after the start of the activities and approved by the JU.

Furthermore the M&P activities in the project shall support the safe inclusion of the partner's technology into the complete H/C.

Certification

- Design Organization Approval (DOA).
- Product Organization Approvals (POA).
- Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004)
- Qualification as Material and Ground Testing Laboratory of reference aeronautical companies (i.e. ISO 17025 and Nadcap).

Weight

The target is to obtain the lowest weight as possible for the proposed component compliant with technical requirements and compatible with a serial aeronautical production. The applicant(s) shall provide an estimated maximum weight of its proposed component. This value will be updated before T0 regarding the design data available at this time, the difference with the weight provided with the offer shall be substantiated and the new weight figure will have to be agreed with the Topic Manager.

For the Preliminary Design Review (PDR), the Partner shall provide a detailed weight breakdown of the component in accordance with the technology, the technical requirement and the interfaces agreed with the leader. The difference with the weight agreed at T0 will be substantiated and submitted to the agreement of the Topic Manager.

For the Critical Design Review (CDR), the Partner shall provide an update of the weight breakdown with a substantiation of the difference with PDR version. If an update of the overall weight is necessary, it will be submitted to the agreement of the Topic Manager.



The components for the flying demo will be delivered with a weight record sheet, deviation with the maximum weight agreed during CDR will be substantiated. At the end of the contract, the Partner shall provide a weight estimation of the component for a production part in accordance with the lessons learned during the development.

Recurring cost estimation

The target is to obtain the optimum between the level of performances of the fast rotorcraft and the cost of the potential product.

For the PDR, the Partner will provide an estimation of the recurring cost of the component on the basis of the assumptions given by the Topic Manager. An up-date will be provided for CDR and at the end of the demonstration phase.

Data management

The Topic Manager will use the following tools for drawing and data management:

- CATIA V5 R21
- VPM
- Windchill

The Partner will provide interface drawings and 3D model for digital mock-up in CATIA V5 R21. The data necessary for configuration management have to be provided in a format compatible with VPM and Windchill tool.

Eco-design

Capacity of performing Life Cycle Analysis (LCA) to define environmental impact (energy, VOC, waste, etc) of technologies. This approach will be integrated during design & manufacturing phases. The Topic Manager will be able support LCA approach (Methodologies training or pilot cases). Capacity to monitor and decrease the use of hazardous substances e.g. compliance with REACH regulation.

X. Fuel bladder tanks for a fast compound rotorcraft

Type of action (RIA or IA)	IA		
Programme Area	FRC (LifeRCraft)		
Joint Technical Programme (JTP) Ref.	FRC 2.7 – Power Plant		
Indicative Funding Topic Value (in k€)	800 k€		
Duration of the action (in Months)	48 months	Indicative Date²⁸	Start Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-FRC-02-12	Fuel bladder tanks for a fast compound rotorcraft
Short description (3 lines)	
The Fast Rotorcraft project shall be equipped with 5 fuel tank bladders which shall be designed and manufactured within this call for Partner. The tank bladders shall conform with CS29 and shall use as far as possible innovative materials with low VOC emission.	

²⁸ The start date corresponds to actual start date with all legal documents in place.



1. Background

The **Fast Rotorcraft** project aims at demonstrating that the compound rotorcraft configuration implementing and combining cutting-edge technologies as from the current Clean Sky Programme opens up new mobility roles that neither conventional helicopters nor fixed wing aircraft can currently cover in a way sustainable for both the operators and the industry.

The project will ultimately substantiate the possibility to combine in an advanced rotorcraft the high cruise speed, low fuel consumption and gas emission, low community noise impact, and productivity for operators. A large scale flightworthy demonstrator embodying the new European compound rotorcraft architecture will be designed, integrated and flight tested.

2. Scope of work

The subject of this Call for Partner covers all activities needed for developing and manufacturing the fuel tanks as part of the High Speed Rotorcraft LifeRCraft IADP. Therefore activities such as engineering activities, manufacturing and test are integral parts of this project.

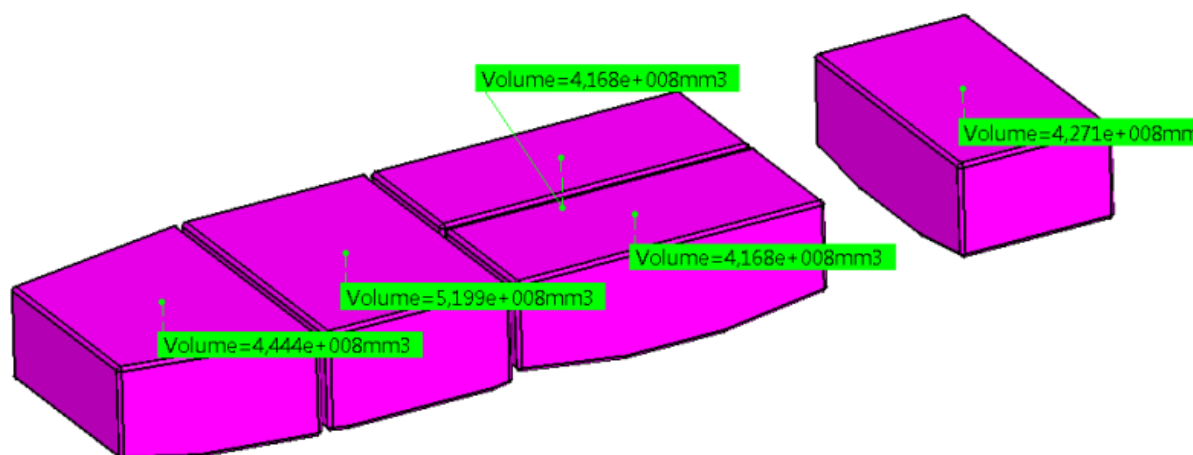
In addition to the technical activities the relevant management activities have to be performed also.

Tasks		
Ref. No.	Title - Description	Due Date
1	Design & Development of 5 fuel tanks for the high speed compound helicopter. The development has to be done in close cooperation with the design responsible of the FRC Fuselage.	T ₀ +9
2	Manufacture of the fuel tanks	T ₀ +24
3	Qualification of the fuel tank bladders	T ₀ +30
4	Support of flight demonstrator Assembly and Tests	T ₀ +48

Preliminary Tank Architecture:

The preliminary fuel tanks architecture is shown below.

The final architecture will be confirmed during the project.



Requirements:

Task 1 – Design & Development:

The fuel tanks shall be designed and manufactured to fulfill the following requirements:

- Compliance to the applicable CS29 fuel system requirements
- Crash resistant acc. to CS29.952 (including interfaces to structure)
- Fuel tank material suitable for the application (e.g. TSO C-80 or equivalent)
- Fuel tanks shall be capable of operation within a temperature range of -40°C to +55°C
- Integration of interfaces for tank-to-tank interconnection, fuel supply/distribution and ventilation
- Integration of interfaces for refuelling (gravity and/or pressure refuelling)

- Innovative materials with the following properties shall be proposed:
 - o low VOC (Volatile Organic Component) emission during manufacturing
 - o optimized weight and mechanical properties
- Conventional material layup shall be available as risk mitigation
- The total capacity of the fuel tanks shall be aprox. 2100 litres (the required expansion space is not part of the fuel tanks)
- 3D models of each tank as well as of the inner tank volume shall be established
- The fuel tank arrangement is shown in on previous page

The development shall be done in close cooperation with the Core partner in charge of the FRC Fuselage and with the Topic Manager to ensure the proper integration of the tanks into the structure incl. all necessary interfaces and interconnections.

The tank design shall respect the possible high pitch angles of $\pm 20^\circ$ which are typical for the compound rotorcraft demonstrator and the resulting impacts on unusable fuel and fuel sloshing. The fuel tanks shall be optimized with respect to minimum unusable fuel and total capacity.

Data management:

The Topic Manager will use the following tools for drawing and data management:

- CATIA V5 R21
- VPM
- Windchill

The Partner will provide interface drawings and 3D model for digital mock-up in CATIA V5 R21. The data necessary for configuration management have to be provided in a format compatible with VPM and Windchill tool.

Weight:

The target is obtained the lowest weight as possible for the proposed component compliant with technical requirements and compatible with a serial aeronautical production.

The applicant(s) shall provide an estimated maximum weight of its proposed component. This value will be updated before T0 regarding the design data available at this time, the difference with the weight provided with the offer shall be substantiated and the new weight figure will have to be agreed with the Topic Manager.

For the PDR, the Partner shall provide a detailed weight breakdown of the component in accordance with the technology, the technical requirement and the interfaces agreed with the leader. The difference with the weight agreed at T0 will be substantiated and submitted to the agreement of the Topic Manager.

For the CDR, the Partner shall provide an update of the weight breakdown with a substantiation of the difference with PDR version. If an update of the overall weight is necessary, it will be submitted to the agreement of the Topic Manager.

The components for the flying demo will be delivered with a weight record sheet, deviation with the maximum weight agreed during CDR will be substantiated.

At the end of the contract, the Partner shall provide a weight estimation of the component for a production part in accordance with the lessons learned during the development.

Eco-design

Capacity of performing Life Cycle Analysis (LCA) to define environmental impact (energy, VOC, waste ...) of technologies.

This approach will be integrated during design & manufacturing phases. The Topic Manager will be able support LCA approach (Methodologies training or pilot cases).

Capacity to monitor and decrease the use of hazardous substances e.g. compliance with REACH regulation.

Task 2 - Manufacturing:

- The partner shall hold an approved POA for fuel tanks and shall manufacture the tanks acc. to the applicable requirements of EASA part 21
- Necessary tooling for the manufacturing of the tanks is under partner responsibility and tooling shall be covered as part of this call
- Each tank shall undergo a final acceptance test before delivery

Recurring cost estimation:

The target is to obtain the optimum between the level of performances of the fast rotorcraft and the cost of the potential product.

For the PDR, the Partner will provide an estimation of the recurring cost of the component on the basis of the assumptions given by the Topic Manager. An up-date will be provided for CDR and at the end of the demonstration phase.

Task 3 - Qualification:

- Fuel tank material must be shown to be suitable for the application (CS29.963) and must be compatible with jet fuels and additives
- Fuel tank material shall be compatible with recent alternative/synthetic fuels in accordance with ASTM D7566
- Fuel tanks must be tested acc. to the applicable requirements of CS29

Mandatory tests:

- Pressure test acc. to CS29.965
- Stand alone drop test of at least one fuel bladder (most critical one) acc. to CS29.952 to show crash resistance of fuel tanks. Necessary interfaces e.g. equipment to be respected.
- Drop test of most critical tank with surrounding structure acc. to CS29.952 to show crash resistance of fuel tanks. Necessary interfaces e.g. equipment plate, surrounding structure to be respected during the test.

Task 4 – Support of flight demonstrator Assembly and tests:

The partner shall provide technical support during the installation of the fuel tanks in the prototype aircraft and during flight testing.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables mandatory			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
	Preliminary 3D concept with first estimates of capacity and weight	CATIA V5 R21 Model	T ₀ +5
	Detailed 3D models for each tank + inner volume	CATIA V5 R21 Model	T ₀ +9
	Detailed 2D drawings	Document	T ₀ +9
	At least 1 tank bladder (B1 model, most critical one) for stand-alone drop test of tank bladder	Hardware	T ₀ +12
	At least 1 tank bladder (most critical one) for drop test with surrounding structure (acc. CS29.952)	Hardware	T ₀ +18
	5 Fuel tanks (one of each - B2 models with flight clearance for demonstrator)	Hardware	T ₀ +24
	Qualification Documents (QTPs, QTRs, Prel-DDP with Safety of Flight Documentation)	Document	T ₀ +30

Milestones (when appropriate)			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
	Kick Off Meeting (KOM)	MS	T ₀ +1
	Preliminary Design Review (PDR)	MS	T ₀ +3
	Critical Design Review (CDR)	MS	T ₀ +9
	First Article Inspection (FAI) B1 models	MS	T ₀ +14
	First Article Inspection (FAI) B2 models	MS	T ₀ +24
	Qualification Review (QR) and SoF (Safety of Flight Documents delivery)	MS	T ₀ +30

4. Special skills, Capabilities, Certification expected from the Applicant(s)

The Topic Manager is the responsible in front of the airworthiness agency, and it is therefore mandatory for the Partner to support the Topic Manager w.r.t. all certification related activities in relation with the fuel tanks. Therefore the Partner has to provide all documentation necessary to achieve permit to fly:

- Providing material data which are required to achieve a permit to fly
- Using material, processes, tools, calculation tools etc. which are commonly accepted in the aeronautic industry and certification authorities
- Acting interactive with TOPIC MANAGER at any state of work
- Access to the production and test sites
- The Partner has to perform the updates of documentation in case of in-sufficient documentation for authorities.

Special Skills:

- Experience in design and manufacturing of fuel tanks for aircraft / rotorcraft
- Design tools of the aeronautical industry (i.e. CATIA V5)
- Competence in management of complex projects of research and manufacturing technologies
- Experience with TRL Reviews or equivalent technology readiness assessment techniques in research and manufacturing projects for aeronautical industry
- Proven experience in collaborating with reference aeronautical companies with industrial air vehicle developments with "in – flight" components experience
- Capacity to support documentation and means of compliance to achieve experimental prototype "Permit to Fly" with Airworthiness Authorities (i.e. EASA, FAA and any others which may apply)
- Design Organization Approval (DOA).
- Product Organization Approvals (POA).
- Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004)

Material and Processes:

In order to reach the main goals of the project two major aspects have to be considered for materials and processes, namely: maturity and safety for the project.

Because of the ambitious plan to develop a flying prototype in a short time frame, the manufacturing technology of the Partner must be on a high maturity level (TRL4) in order to be able to safely reach the required technology readiness for the flying demonstrator.

To secure this condition, the core Partner will have to demonstrate the technology readiness for his proposed materials and process and manufacturing technology with a TRL review, to be held together with TOPIC MANAGER.

The TRL review must be held within one year after beginning of the project and must confirm a maturity of TRL5 or at least TRL4 if a solid action plan to reach TRL5 within the scope of one further year and finally meet the TRL target for the demonstrator is validated and accepted by TOPIC MANAGER.

Furthermore, since the schedule of the project and the budgetary framework don't allow for larger unanticipated changes during the project, it is required that at the start of activities the partner demonstrates his capability to develop and manufacture the required items with a baseline technology which will be a back-up solution in case the new technology to be introduced proves too challenging.

This back-up plan, which shall secure the meeting of the project goals shall also be agreed between TOPIC MANAGER and the Partner within half a year after start of the activities and approved by the JU.

XI. HVDC Generator

Type of action (RIA or IA)	IA		
Programme Area	FRC (LifeRCraft)		
Joint Technical Programme (JTP) Ref.	WP 2.8 Electrical System		
Indicative Funding Topic Value (in k€)	1200 k€		
Duration of the action (in Months)	42 months	Indicative Start Date²⁹	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-FRC-02-13	HVDC Generator
Short description (3 lines)	
Objective: to design, develop, manufacture, test and qualify up to TRL6 a High Voltage Direct Current (HVDC) controlled Generator (HVGEN) intended to be installed on a Heavy Class Helicopter (H/C) for a Flight Demonstration.	

²⁹ The start date corresponds to actual start date with all legal documents in place.

1. Background

The activity of this sWP 2.8.1.4 is a part of the “electrical Generation and Distribution & Lighting system” for the Life Craft demonstrator: WP 2.8.1.

WP 2.8.1 Organization:

2.8.1	Electrical Generation, distribution	
2.8.1.1	System activity and adaptation	Activity AH: Architecture, load analysis, system spec, equipment spec, partner selection, partner follow up, verification plan for Permit to flight - Extrapolation to serial Aircraft.
2.8.1.2	Power management strategy & electrical System optimization	Activity partner: Electrical system component optimization and energy management strategy. Validation of optimization and strategy with simulation, verification on bench
2.8.1.3	HVDC Generators	Activity partner: 20/40kVA HVDC generator
2.8.1.4	Engine starter generator	Activity partner: Starter generator - starter HVDC, generator 28Vdc
2.8.1.5	Power storage	Activity partner: HVDC battery for engine starting
2.8.1.6	HVDC Network management	Activity partner: HVDC electrical master box & secondary distribution (SSPC)
2.8.1.7	Power converter	Activity partner: HVDC/28Vdc converter AC115Vac/HVDC converter HVDC/115vac converter
2.8.1.8	Interior and exterior lighting	Activity AH: Interior and exterior lighting system for demonstrator
2.8.1.9	Laser landing light	Activity partner: Laser landing light for demonstrator
2.8.1.10	Electrical system testing	Activity AH: Bench test integration and verification for permit to flight

The H/C will include on-board two electrical networks:

- The 270VDC H/C network compliant with MIL-STD-704-F.
- The 28VDC H/C network compliant with EN2282.

The HVGEN will be connected to only the 270VDC H/C network (it is autonomous from 28VDC network).

2. Scope of work

Objective

The aim of this document is to detail the activities required for designing and developing up to TRL6 an innovative High Voltage Direct Current (HVDC) controlled Generator (HVGEN) to be integrated into the life craft helicopter.

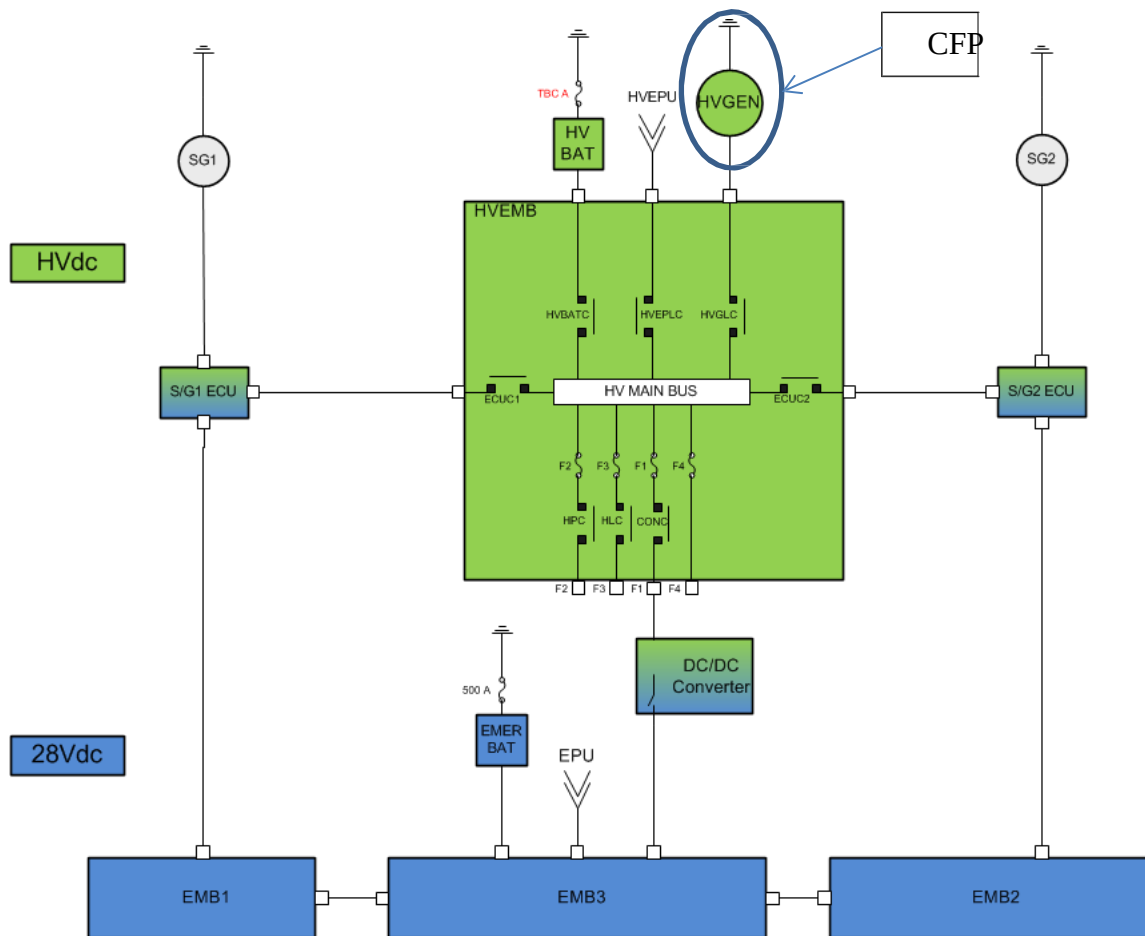
The controlled Generator is a major component of the HVDC Network.

The aims of the HVDC Network are:

- To manage power sources connection to the network
- To satisfy the electrical power protection and distribution requirements both in flight and on ground
- To satisfy the engine starting operation requirements
- To improve safety conditions on board in observance of official safety regulations:
 - Compliance with CS29: Certification Specification for Large Rotorcraft
 - Compliance with FAR PART 29
- To improve reliability and reduce maintenance costs

HVDC Network management system description:

The following picture depicts the electrical system of the demonstrator:



The electrical system supplies all installed equipment from available power generation equipment: starter-generators (SG1 and SG2), HVDC generator (HVGEN), batteries (HV BAT and EMER BAT) or External Power Unit (EPU); while satisfying safety conditions. The HVDC Network management system is composed of one High Voltage Direct Current Electrical Master Box (HVEMB).

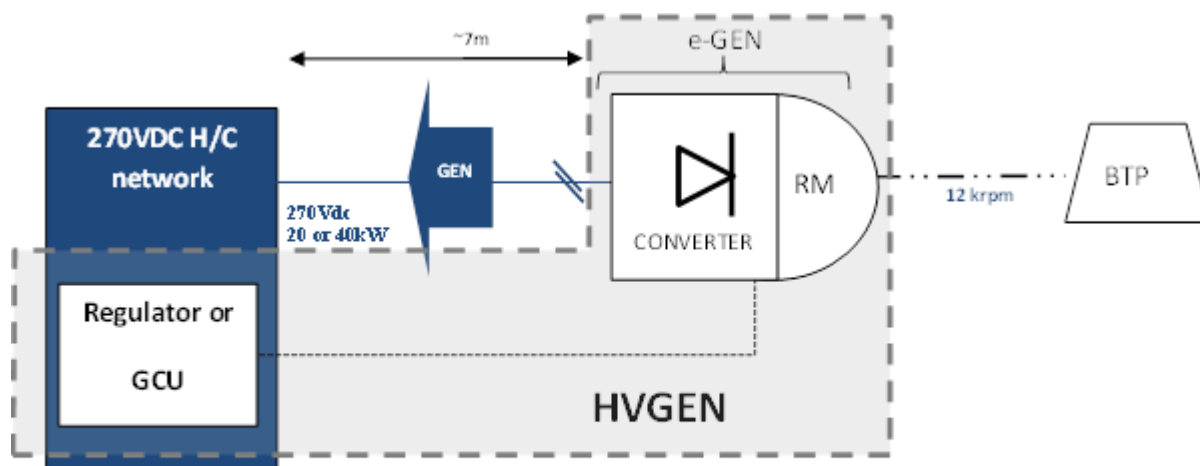
The following guidelines establish the main operational modes of the HVDC Network management system:

- Under normal operation of the helicopter, the HVEMB provides power to high power consumers via dedicated interfaces (F2, F3 and F4). The 28Vdc network is supplied via the DC/DC Converter and the both starter generator.
- In case of a single starter-generator failure, EMB3 is automatically reconfigured so that it can supply power from the DC/DC Converter to that side of the network (either EMB1 or EMB2).
- If both starter-generators fail, EMB3 is reconfigured so that the HVdc generator, via the DC/DC converter, supplies the essential equipment necessary to ensure the flight safety ("Emergency flight" operation). A secondary backup solution is implemented by means of the 28Vdc emergency battery.
- On ground, before starting the engine, power supply to the distribution network is provided via

the HV BAT and/or EPU.

2.2. HVGEN Technical description

2.2.1 General description



As described on above picture the HVGEN is composed of two components:

- Regulator or Generator Control Unit (GCU), installed in the avionic bay; and
- the electrical GENERator (e-GEN) including: Rotating Machine (RM) and integrated converter, installed in the H/C upper deck zone on the Main Gear Box (MGB) *(if necessary, the converter could be installed in the Cabin - not preferred installation due to high penalty on cables weight – to be discussed with Airbus Helicopters during design phase)*.

The main function of the HVGEN is to provide electrical power to the 270 HVDC H/C electrical network.

2.2.2 List of Abbreviations

CAT	Catastrophic
CBIT	Continuous Built-in Test
e-GEN	Electrical GENERator
FDAL	Function Development Assurance Level
GM	Generator Mode
HAZ	Hazardous
H/C	Helicopter
HVDC	High Voltage Direct Current
HVGEN	High Voltage GENERator

IBIT	Initiated Built-in Test
LRU	Line Reparable Unit
LVDC	Low Voltage Direct Current
MAJ	Major
MIN	Minor
MTBF	Mean Time Between Failures
PBIT	Power Built-in Test
RM	Rotating Machine
TBO	Time Between Overhaul
Vdc	Volts direct current

2.2.3 Norms and standards

ARP4761	Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment
ARP4754 A	Certification Considerations for Highly-Integrated or Complex Aircraft Systems
DO254	Design assurance guidance for airborne electronic hardware
DO178	Software considerations in airborne systems and equipment certification
MIL-STD-704F	Aircraft electric power characteristics, 30 December 2008
RTCA/DO 160F	Environmental conditions and tests procedures for airborne equipment
MIL-HDBK-217F	Military Handbook Reliability Prediction of Electronic Equipment, 2 December 1991.
ANSI/VITA 51.1-2008	American National Standard for reliability prediction MIL-HDBK217 subsidiary specification
RIAC-HDBK-217Plus	Handbook of 217Plus TM Reliability Models Ed. May 2006
EN 60664-1	Insulation coordination for equipment within low voltage systems

2.2.4 Main performance requirements

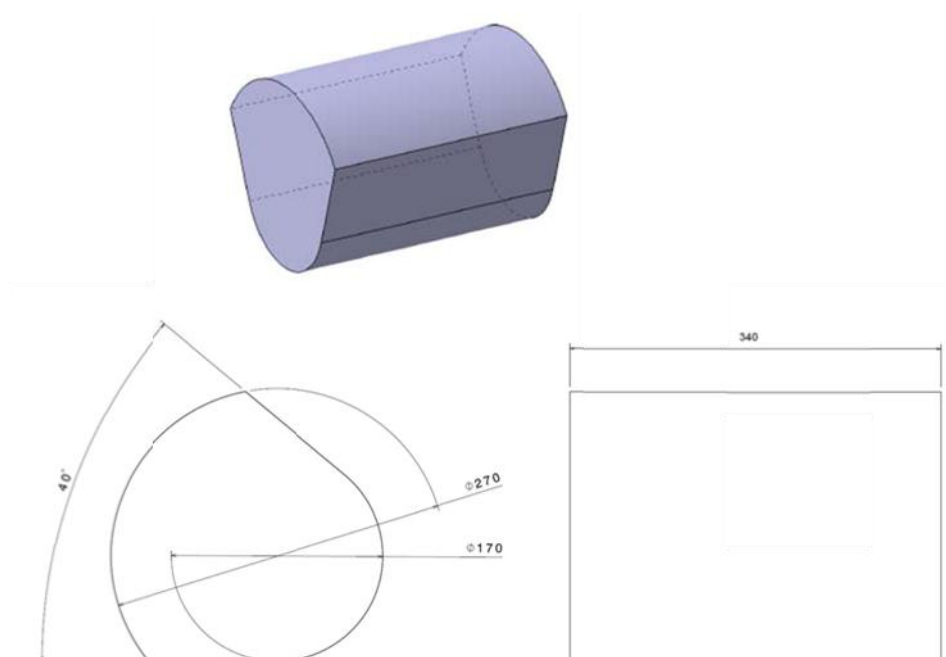
The HVGEN main high level technical characteristics are the following with :

- Req. 1: Rated output voltage: $U_r=270\text{VDC}$ (adjustable) according to MIL-STD-704-F
- Req. 2: Output nominal speed: $GM=12\,000$ rpm corresponding to 100%
- Req. 3: Speed range: as per below table

SPEED RANGE	MAXIMUM DURATION TIME/MISSION	OCCURRENCE RATE/FH
$125\% \geq Y > 118\%$	Remains burst contained for 5 min	10^{-5}
$118\% \geq Y > 110\%$	30s	10^{-2}
$110\% \geq Y > 104,5\%$	6 min	10^{-1}
$104,5\% \geq Y > 90\%$	Continuous	1
$90\% \geq Y > 75,4\%$	30 min	1

- Req. 4: Electrical rated Current generated: $I_n=75\text{A}$ (20kW) up to U_r (the partner will provide a pre-sizing report for $I_n=150\text{A}$ (40kW) up to U_r by highlighting the impact and limitations)

- Req. 5: Output voltage accuracy: $\pm 1\%$ of Point Of Regulation reference value
- Req. 6: Overload:
 - 3 times $I_n \times 150\%$ for 5 minutes for at least 234Vdc TBC with no impact on HVGEN reliability
 - 3 times $I_n \times 210\%$ for at least 6 seconds for at least 216Vdc TBC with no impact on HVGEN reliability
- Req. 7: Efficiency $\geq 80\%$
- Req. 8: Torque ripple $\leq 10\%$ rated Torque
- Req. 9: Over-temperature protection: HVGEN protected from over-temperature that can lead to permanent damage of the HVGEN or limit its safety and reliability
- Req. 10: Short-circuit capacity protection: 3 times the following conditions:
 - $3 \times I_n < I < 7 \times I_n$
 - as per below $T^\circ\text{C}$ requirement
 - at 12 000rpm
- Req. 11: Testability: at least PBIT and CBIT
- Req. 12: Mechanical interface with MGB:
 - Direction of rotation: counter-clockwise when looking towards the HVGEN flange
 - Shaft spline compliant with 14Zx1,5mx30Rx5d ISO4156 TBC
 - Shaft stiffness: 30 N/mm maximum TBC
 - Coaxiality with $\varnothing 120\text{H}8$: $\varnothing 0.3\text{mm}$ maximum TBC
 - Perpendicularity with contact surface: 0.1mm maximum TBC
 - Maximum Shear section torque: [60N.m;75N.m]
 - e-GEN Removal and replacement within 30 minutes
 - Max galvanic couple $\leq 250\text{mV}$
 - Bonding complying with HS213 (58 or 60)
- Req. 13: MTBF:
 - E-GEN $\geq 5\,000\text{fh}$ (demonstrator)
- Regulator or GCU $\geq 10\,000\text{fh}$ (demonstrator)
 - Req. 14: TBO $\geq 5000\text{fh}$. This requirement shall be taken into for the design and justify by analysis but will not be demonstrated for the permit to fly
 - Req. 15: RM Lubrication: Grease
 - Req. 16: Weight objective for e-GEN+(Regulator or GCU): 12kg
 - Req. 17: Volume objective:
 - e-GEN=as defined in below drawing (*detailed design shall be defined with Airbus Helicopters*)
 - Regulator or GCU=max. 1L/kg



- Req. 18: Cooling: e-GEN=self-air-cooled via a duct from outside, Regulator or GCU= self- cooled
- Req. 19: Max T°C: outside air max T°C ≤55°C (for e-GEN and Regulator/GCU ambient **min and max** T°C refer to environmental table)
- Req. 20: HVGEN operating and storage times for his whole 30 years in service use as per below

In flight operating time per year	On ground operating time per year	Not operating time (storage) per year
1 200 hours	150 hours	7 410 Hours

2.2.5 Main safety requirements

- Req. 21: FDAL: as per below table

Ref	HVGEN function	F DAL
F1	Generator Mode	B
F1.1	To distribute electrical power generation to H/C network	B (Independent from 1.2)
F1.2	To monitor the electrical power generation distribution	B (Independent from 1.1)
F1.2.1	Overvoltage protection	B (Independent from 1.1)
F1.2.2	Short-circuit protection	
F2	Fire or overheating	A

Ref	HVGEN function	F DAL
F3	Interface with helicopter on-board electrical network (270Vdc and 28Vdc network)	A

- Req. 22: Fail-safe constraint: no single failure directly attributable to this equipment can lead to a HAZ or CAT situation for the Helicopter for each flight
- Req. 23: Fire/hot surface for RM:
 - Behaviour without HVGEN failure:
 - o HVGEN not activated: RM temperature < ambient + 15°C.
 - o HVGEN activated: RM shall not lead to hot surfaces/points higher than 280°C
 - Behaviour in case of HVGEN failure(s):
 - o No single failure shall lead to create sparks and overheating higher than 165°C
 - o Upon single failure, RM temperature shall not exceed 280°C
- Req. 24: Induced skin T°C on H/C structure for Regulator or GCU ≤150°C
- Req. 25: At least, 3 independent failures shall be necessary to create an equipment fire
- Req. 26: The equipment shall be self-extinguishing and shall be at least fire resistance category C (DO160)
- Req. 27: No emission (inside and outside) of: flamme, smoke, sparks or toxic vapors
- Req. 28: **Average** ambient T° as per below

Applicability for equipment	Average temperature in flight	Average temperature on ground	Average temperature during storage
air inlet (e-GEN)	35°C	35°C	30°C
ambient (e-GEN)	80°C	90°C	35°C
ambient (regulator)	50°C	50°C	35°C

2.2.6 Main Qualification requirements

- Req. 29: The following shall be demonstrated before prototype first flight on critical equipment items. Such equipment items are those whose malfunction may endanger the flight of the prototype. Safety department shall be consulted to verify this criterion.
 - o Altitude-pressure (AH levels)
 - o Temperature (AH levels)
 - o Vibration (group of the helicopter as a minimum) AH levels)
 - o Shock: landing, load factor (AH levels)
 - o Conducted emission (AH levels)
 - o Electrical fields emission (AH levels)

- Voltage Spikes (DO160G / ED14G Section 17, Cat A)
- RF conducted susceptibility (DO160G / ED14G Section 20, Cat W)
- RF radiated susceptibility (DO160G / ED14G Section 20, Cat G)
- Ground Reference Fluctuations (GRF) AH levels,
- Another AH level, if applicable according to helicopter electrical architecture and equipment installation.

2.2.7 Main Environmental requirements

- Req. 30: The below table define the environmental requirements applicable for the design to be taken into account and justified (via calculation, simulation etc...) during the design phase. The requirements applicable for the H/C flight clearance are described in above §2.2.6.

Nota:

- "NA" means that the requirement is not asked in the specification of the equipment.
- "Cat xxx" means that the equipment is exposed to the environment and defines the category and the associated value to be chosen in the dedicated paragraph.
- If not explicitly written in the matrix, all requirements specified in this document are applicable, meaning that if the column is empty, the requirement is applicable without any need of detail.
- Compliance to [CONST Env-COM N°x], [CONST Env-Gen N°x] or [CONST EMC N°x] can be claimed only if all associated sub requirements are declared compliant. If not, non-compliance or partial compliance shall be declared

Req. N#	Topics	Requirements Title / Summary	Applicability/Level for e-GEN	Applicability/Level for Regulator or GCU
[CONST ENV_COM N°1]	Performance s	Compliance with AH levels conditions		
		Representativeness of EUT with serial production		
		Representativeness of test setup and test conditions		
[CONST ENV_COM N°2]	Qualification General Requirements	Bonding measurement		
		Qualification plan content		
		Analysis to be furnished in the qualification plan		
		Analysis content		
		Qualification test procedure content		
		Qualification test report content		
		DDP content		
[CONST ENV_COM	Equipment Modification	Non-regression for modified equipment		
		Non-regression demonstration		

Req. N#	Topics	Requirements Title / Summary	Applicability/Level for e-GEN	Applicability/Level for Regulator or GCU
N°3]		Alternative to non-regression demonstration		
[CONST ENV_COM N°4]	Flight Clearance Pre-Qualification	Flight Clearance for non- critical equipment	NA	
		Flight Clearance for critical equipment		
		Flight Clearance for equipment, scope of the flight		
[CONST Env-Gen N°1]	General requirements for thermal conditions	High & low temp. tests – Temperature chamber		
		High & low temp. tests – Good operation check		
		High & low temp. tests – Air temperature measurement		
		High & low temp. tests – Standard ambient temperature definition		
		High & low temp. tests – Temperature tolerance		
		High & low temp. tests – Equipment temperature stabilization		
		High & low temp. tests – Test procedure & test report		
		High & low temp. tests – Data to be gathered in test report		
		High & low temp. tests – Acceptance criteria		
		Equipment design request		
		Thermal model		
[CONST Env-Gen N°2]	Temperature and altitude DO160G / ED14G Section 4	Section 4 - Storage (ground survival) low temperature	B2	B2
		Section 4 - Short-time operating and operating low temperature	B2	B2
		Section 4 – Low temperature procedure	See AH levels	See AH levels
		Section 4 – Low temperature acceptance criteria		
		Section 4 - Storage (ground survival) high temperature	Cat B3: Temperature TBC	Cat B2
		Section 4 - Short-time operating high	Cat B3:	Cat A3

Req. N#	Topics	Requirements Title / Summary	Applicability/Level for e-GEN	Applicability/Level for Regulator or GCU
		temperature	Temperature TBC	
		Section 4 - Operating high temperature	Cat B3: Temperature TBC	Cat B2
		Section 4 – High temperature procedure	See AH levels	See AH levels
		Section 4 - High temperature values	See AH levels	See AH levels
		Section 4 – High temperature acceptance criteria		
		Section 4 – Ventilation loss procedure	NA	NA
		Section 4 – Ventilation loss acceptance criteria	NA	NA
		Section 4 - Altitude/pressure variation procedure		
		Section 4 – Altitude/pressure variation acceptance criteria		
		MIL-STD-810G method 500.5, procedure I - Aircraft transport procedure		
		MIL-STD-810G method 500.5, procedure I - Aircraft transport acceptance criteria		
[CONST Env-Gen N°3]	Temperature variation DO 160G / ED14G Section 5	Section 5 - Temperature variation procedure	Cat A	cat B
		Section 5 - Temperature variation acceptance criteria		
[CONST Env-Gen N°4]	Humidity DO 160G / ED14G Section 6	Section 6 – Humidity procedure	Cat C	cat B with AH levels adaptations
		Section 6 – Humidity acceptance criteria		
[CONST Env-Gen N°5]	Fungus DO160G / ED14G Section 13	Section 13 - Fungus procedure	Cat F	cat F
		Section 13 - Fungus acceptance criteria		
[CONST Env-Gen N°6]	Salt spray DO160G / ED14G Section 14	Section 14 - Salt spray procedure	Cat T	cat S with AH levels adaptations
		Section 14 - Salt spray acceptance criteria		
[CONST Env-Gen N°7]	Sand and dust DO160G / ED14G	Section 12 - Sand and Dust procedure	Cat S	cat S
		Section 12 - Sand and Dust acceptance		

Req. N#	Topics	Requirements Title / Summary	Applicability/Level for e-GEN	Applicability/Level for Regulator or GCU
	Section 12	criteria		
[CONST Env-Gen N°8]	Waterproofness DO160G / ED14G Section 10	Section 10 - Waterproofness procedure	Cat R	cat W
		Section 10 - Waterproofness acceptance criteria		
[CONST Env-Gen N°9]	Icing DO160G / ED14G Section 24	Section 24 - Icing case n°1 - Procedure	NA	NA
		Section 24 - Icing case n°1 - Acceptance criteria	NA	NA
		Section 24 - Icing case n°2- Procedure	NA	NA
		Section 24 - Icing case n°2 - Acceptance criteria	NA	NA
		Section 24 - Icing case n°3- Procedure	NA	NA
		Section 24 - Icing case n°3 - Acceptance criteria	NA	NA
[CONST Env-Gen N°10]	Fluid susceptibility DO160G / ED14G Section 11	Section 11 - Fluid susceptibility procedure	Cat F	Cat F
		Section 11 - Fluid susceptibility acceptance criteria		
[CONST Env-Gen N°11]	Solar radiation	Solar radiation - Actinic effect procedure	NA	NA
		Solar radiation - Actinic effect acceptance criteria	NA	NA
		Solar radiation - Thermal effect – procedure	NA	NA
		Solar radiation - Thermal effect acceptance criteria	NA	NA
[CONST Env-Gen N°12]	Explosion proofness DO160G / ED14G Section 9	Section 9 - Explosion proofness procedure	Cat E or H	Cat E or H
		Section 9 - Explosion proofness acceptance criteria		
[CONST Env-Gen N°13]	Fire resistance DO160G / ED14G Section 26	Section 26 - Fire resistance procedure	Cat B or C (TBC)	Cat C
		Section 26 - Fire resistance acceptance criteria		
[CONST Env-Gen N°14]	Vibration DO160G / ED14G Section 27	Test report for mechanical requirements		

Req. N#	Topics	Requirements Title / Summary	Applicability/Level for e-GEN	Applicability/Level for Regulator or GCU
Gen N°14]	O160G / ED14G Section 8	Section 8 - Vibrations procedure for known helicopters	Zone C; group TBC	Zone A; group TBC
		Section 8 - Vibrations procedure for unknown helicopters		
		Vibrations acceptance criteria		
[CONST Env-Gen N°15]	Shocks DO160G / ED14G Section 7	Section 7 - Operational shocks (landing) procedure	cat D	cat D
		Section 7 - Operational shocks (landing) acceptance criteria		
		Section 7 - Crash safety procedure	cat E	cat E
		Section 7 - Crash safety acceptance criteria		
		Section 7 - Constant acceleration procedure		
		Section 7 - Constant acceleration acceptance criteria		
[CONST Env-Gen N°16]	Lighting Direct Effects DO160G / ED14G Section 23	Section 23 - LDE Procedure	NA	NA
		Section 23 - LDE Acceptance criteria	NA	NA
[CONST EMC N°1]	Design	No propagation of energy	-	-
		Design explanation request	-	-
		Reserve polarity	-	-
		Power supply return insulation	-	-
		Primary bonding path	-	-
		Wiring (design)	-	-
		LIE protection	-	-
		LIE exposed area	-	NA
		Bonding (design)	-	-
[CONST EMC N°2]	Test setup - Wiring Configuration	HW & SW configuration	-	-
		Simulation load	-	-
		Wiring representativeness of helicopter configuration	-	-
		Length of interconnecting wiring	-	-
		Level A system wiring	-	-

Req. N#	Topics	Requirements Title / Summary	Applicability/Level for e-GEN	Applicability/Level for Regulator or GCU
		Length of power supply leads	-	-
		Power supply lead within interconnecting bundle	-	-
		Test with no over shield	-	-
		Individual shield bonding	-	-
[CONST EMC N°3]	Test Setup - Grounding Sub System Test	Representativeness of equipment grounding	-	-
		Minimal value for grounding	-	-
		Equipment grounding – test setup	-	-
		Length of bonding wire	-	-
		Bonding value provided in QTR	-	-
		Test bonding value as reference for serial production	-	-
[CONST EMC N°4]		Level A sub system test	-	-
[CONST EMC N°5]	Emission of Radio Frequency Energy adaptation of DO160G / ED14G Section 21	Section 21 - CE test procedure	-	-
		Section 21 - CE limits	- Category P extended for cables interfaces between RM and regulator - Category H for other cables interfaces.	
		Section 21 - CE acceptance criteria	-	-
[CONST EMC N°6]		Section 21 - RE test procedure	-	-
		Section 21 - EUT orientation	-	-
		Section 21 - RE limits	Category P (Extended Frequency Range)	
		Section 21 - RE acceptance criteria	-	-
[CONST EMC N°7]	Emission of Spikes on Power Leads	Emission of Spikes - Test procedure	-	-
		Emission of Spikes - Limits	-	-
		Emission of Spikes - Acceptance criteria	-	-
[CONST EMC N°8]	Magnetic Sensor Disturbance	Section 15 - Test procedure	-	-
		Section 15 - Limits	Category Y.	
		Section 15 - Acceptance criteria	-	-

Req. N#	Topics	Requirements Title / Summary	Applicability/Level for e-GEN	Applicability/Level for Regulator or GCU
	adaptation of DO160G / ED14G Section 15			
[CONST EMC N°9]	Voltages Spikes DO160G / ED14G, Section 17	Section 17 - Test procedure	-	-
		Section 17 - Applicability to all 28V I/O	-	-
		Section 17 - Limits	Category A	
		Section 17 - Acceptance criteria	-	-
[CONST EMC N°10]	AF Conducted Susceptibility - Power Inputs	Section 18 - Test procedure	-	-
		Section 18 - Limits	- Category Z for Direct Current - R(CF) for Alternative Current	
	DO160G / ED14G, Section 18	Section 18 - Acceptance criteria	-	-
[CONST EMC N°11]	Induced Signal Susceptibility	Section 19 - Test procedure	-	-
		Section 19 - Limits	Category ZC	
	DO160G / ED14G, Section 19	Section 19 - Acceptance criteria	-	-
[CONST EMC N°12]	Ground Reference Fluctuations	Ground Reference Fluctuations - Test procedure	-	-
		Ground Reference Fluctuations - Limits	For Direct Current and Alternative current	
		Ground Reference Fluctuations - Acceptance criteria	-	-
[CONST EMC N°13]	Radio Frequency Susceptibility	Section 20 - BCI test procedure	-	-
		Section 20 - BCI limits	Category M	
	DO160G / ED14G, Section 20	Section 20 - BCI acceptance criteria	-	-
[CONST EMC N°14]		Section 20 - RS test procedure	-	-
		Section 20 - RS limits	Category R	

Req. N#	Topics	Requirements Title / Summary	Applicability/Level for e-GEN	Applicability/Level for Regulator or GCU		
		Section 20 - RS acceptance criteria	-	-		
[CONST EMC N°15]	ESD	ESD - Applicability of pin injection test	-	-		
	adaptation of DO160G / ED14G, Section 25	ESD - Test procedure	-	-		
		ESD - Pin injection test procedure	-	-		
		ESD - Test limits	Category A			
		ESD - Acceptance criteria	-	-		
[CONST EMC N°16]		HIRF – Exposure duration (level A & B)	The level to apply is the worst FDAL level			
		HIRF - Immunity threshold establishment				
		HIRF - Window effect				
		HIRF - Receivers specific case	NA			
		Military Applications - Applicability				
[CONST EMC N°17]	HIRF Protection	HIRF - BCI test procedure	The level to apply is the worst FDAL level			
		HIRF - Built in redundancy				
		HIRF - BCI test connector by connector				
		HIRF - BCI limits				
		HIRF - BCI limit of exposed wiring (level A)				
		HIRF - CS margin establishment (level A VFR function)	NA			
		HIRF - CS margin establishment (level A IFR function)				
		HIRF - CS margin establishment			The level to apply is the worst FDAL level	
		HIRF - BCI test with no over shield but...				
		HIRF - BCI acceptance criteria				
HIRF - Test report documentation						
[CONST EMC N°18]		HIRF - RS test procedure	The level to apply is the worst FDAL level			
		HIRF - Alternative method to reverberation chamber – EUT orientation				
		HIRF - RS limits				
		HIRF - High frequency >18GHz				
		HIRF - RS margin establishment (level A VFR function)	NA			
		HIRF - RS margin establishment (level A IFR function)				
		HIRF - RS acceptance criteria			The level to apply is the worst FDAL level	
		HIRF - Test report documentation				

Req. N#	Topics	Requirements Title / Summary	Applicability/Level for e-GEN	Applicability/Level for Regulator or GCU		
[CONST EMC N°19]	Lightning Indirect Effects adaptation of DO160G / ED14G, Section 22	LIE - Equipment in flammable vapor area	-	Not applicable		
[CONST EMC N°20]		Pin to case - Test procedure	The level to apply is the worst FDAL level			
		Pin to case - Differential mode				
		Pin to case - Test setup: connection of electrical grounds				
		Pin to case - Monitoring				
		Pin to case - Limits				
		Pin to case - Acceptance criteria				
		LIE - Impedance of I/O under lightning conditions				
[CONST EMC N°21]		Built in redundancy				
		LIE Functional - Test procedure				
		LIE Functional - Power supply test				
		LIE Functional - Interconnecting bundle test				
		LIE Functional - Differential signals				
		LIE Functional - Limits for single & multiple strokes threats				
		LIE Functional - Multiple burst limits				
LIE Functional - Acceptance criteria						
[CONST EMC N°22]	Pyrotechnic Equipment	Pyrotechnic - Test procedure	NA			

3. Activities description

Ref. No.	Title - Description	Due Date
TS 2.8.1.3-1	Kick Off Meeting (KOM) : The objective of this meeting is to: · Formally launch the project phase · Review the Technical documentation · Identification of main technical risks and related activities to address them · Review the detailed development time schedule · Define frequency of intermediate engineering reviews.	T_0
TS 2.8.1.3-2	Progress Report (PR): During the entire project Phase, the partner shall provide every two months a Progress Report.	Every two months from T_0 to T_0+42
TS 2.8.1.3-3	Specification Review: The main objective of this task is to review the customer specification, and describe the product to be design, manufactured, qualified and provided to the customer for testing. → This activity will be closed by a review: Specification Review.	From T_0 to T_0+3
TS 2.8.1.3-4	Preliminary Design: The main objective of this activity is to validate the Equipment requirements and check that equipment design is consistent with these requirements: architecture concept according to performance and safety requirements, sizing, interfaces definition, substantiation of design choice. → This activity will be closed by a review: Preliminary Design Review (PDR)	From T_0+3 to T_0+6
TS 2.8.1.3-5	Critical Design: The main objective of this activity is to realize the detailed design (mechanical, electrical, thermal,...), realise drawings , finalize safety analysis, define verification test procedure for demonstrator equipment, prior to launch equipment manufacturing. → This activity will be closed by a review: Critical Design Review (CDR) n°1	From T_0+6 to T_0+12
TS 2.8.1.3-6	M model manufacturing: Mechanical mock-up identical with the specified Equipment / Sub-system in its form and fit. It is used to validate the installation in the Helicopter, including provisions and harness routing, as well to assess the man machine interface (MMI) and maintainability/accessibility. It is to be installed in the full scale helicopter engineering mock-up.	From T_0+12 to T_0+13
TS 2.8.1.3-7	B1 model manufacturing: Development model identical in form, fit and function with the specified equipment, it might contain non-qualified components, hence is not flight cleared (B1 model). It is primarily used on system test and integration rigs, covering the full range of operation. Prototypes will be used for TRL5 validation on partner's and customer's benches. The partner will have to deliver B1 models to the customer for bench integration tests. → This activity will be closed by a First Article Inspection and deliveries of two B1 models (one for bench and one spare)	From T_0+12 to T_0+18

Ref. No.	Title - Description	Due Date
TS 2.8.1.3-8	B1 model tests at partner's bench to validate TRL5: The partner will realize the necessary bench tests (e.g. functional) with the B1 models to demonstrate the TRL5. → This activity together with TS 2.8.1.3-9 will be closed by a TRL5 review and validation	From T ₀ +18 to T ₀ +23
TS 2.8.1.3-9	Integration tests at Customer's bench to validate TRL5: In parallel of partner's bench test, the partner will support integration tests at customer's bench to demonstrate the TRL5. → This activity together with TS 2.8.1.3-8 will be closed by a TRL5 review and validation	From T ₀ +20 to T ₀ +23
TS 2.8.1.3-10	Loop on Critical Design: Objective of this activity is to define design correction after TRL5 assessment and integration tests in order to prepare B2 model manufacturing (B2 model is a model identical in fit, form and function with the specified equipment model at latest design that will be qualified for flight test clearance). → This activity will be closed by a review: Critical Design Review (CDR) n°2	From T ₀ +20 to T ₀ +25
TS 2.8.1.3-11	B2 model manufacturing: The applicant will have to manufacture B2 models according to design file validated in last Critical Design Review. Prototypes will be used for TRL6 validation on partner's and customer's bench, and customer's flight test demonstrator. → This activity will be closed by a First Article Inspection and deliveries of three B2 models (one for flight test demonstrator, one for customer's test bench and one spare)	From T ₀ +25 to T ₀ +28
TS 2.8.1.3-12	Flight Clearance Tests: Objective of this activity is to perform the necessary qualification tests (e.g. Environment) and analyses to demonstrate B2 models are flight cleared. → This activity will be closed by a Declaration of Design and Performance (DDP).	From T ₀ +28 to T ₀ +31
TS 2.8.1.3-13	Flight test campaign: The applicant will support the customer during flight test campaign. → This activity together with TS 2.8.1.4-14 will be closed by a TRL6 review and validation.	From T ₀ +31 to T ₀ +42
TS 2.8.1.3-14	TRL6 demonstration: The applicant will provide the complementary evidence for TRL6 validation. → This activity together with TS 2.8.1.4-13 will be closed by a TRL6 review and validation.	T ₀ +41
TS 2.8.1.3-15	Extrapolation to serial product : The partner will analyse results of tests done on customer's and partner's benches, and on flight demonstrator in order to identify the action plan and design changes necessary to define a serial product. → This activity will be closed by a Final report	T ₀ +42

4. Major deliverables/ Milestones and schedule (estimate)

4.1. Major Deliverables

Ref. No.	Title - Description	Type	Due Date
Progress Report			
D2.8.1.3 – 1.1	Schedule status	Document	Every two months from T_0 to T_0+42
D2.8.1.3 – 1.2	Technical performance including : o Weight, o Conformity to requirements o Software and/or Hardware problem reports	Document	Every two months from T_0 to T_0+42
D2.8.1.3 – 1.3	Status of the actions (reviews, meetings, coordination memo's...), Technical changes and Pending issues and associated recovery plans (Solution to existing issues, Pending issues, Identification of new issues), Risks and associated mitigation plans	Document	Every two months from T_0 to T_0+42
D2.8.1.3 – 1.4	Meetings status o Meeting held o Meeting planned.	Document	Every two months from T_0 to T_0+42
Specification review Documents			
D2.8.1.3-2.1	Compliance matrix to customer specification	Document	T_0+3
D2.8.1.3-2.2	Product Description with requirements tracking	Document	T_0+3
Preliminary Design Documents			
D2.8.1.3-3.1	Product specification + compliance matrix to Topic requirements + verification plan	Document	T_0+6
D2.8.1.3-3.2	Preliminary design file including: - Architecture choice - Sizing substantiation - Software and/or Hardware architecture - Thermal analysis - SWOT analysis - block diagram - functional description - preliminary results of the Electromagnetic finite element, thermal and other simulations	Document	T_0+6
D2.8.1.3-3.3	Interface Control document (electrical, mechanical, thermal, cooling, ...)	Document	T_0+6
D2.8.1.3-3.4	Preliminary RAMT analysis	Document	T_0+6

Ref. No.	Title - Description	Type	Due Date
D2.8.1.3-3.5	Digital model of the preliminary 3D arrangement (in CATPart or STEP file) with integration in the available volumes	CATPart or STEP file	T ₀ +6
Critical Design Documents			
D2.8.1.3-4.1	Detailed design file & drawings: - Detailed design description - Final compliance Matrix - Final Qualification Plan and the Validation and Verification - 2D Mechanical drawings - 2D Electrical and electronics drawings	Document	T ₀ +12
D2.8.1.3-4.2	Substantiation file including update of: - Architecture choice - Sizing substantiation - Software and/or Hardware architecture - Mechanical static and fatigue substantiations - Final results of the Electromagnetic finite element, thermal and other simulations	Document	T ₀ +12
D2.8.1.3-4.3	Detailed RAMT analysis (SSA, FHA, Fault Trees, FMEA, CCA)	Document	T ₀ +12
D2.8.1.3-4.4	Software and/or Hardware Complex requirement specification and design document if applicable	Document	T ₀ +12
D2.8.1.3-4.5	Qualification test plan and procedures (QP)	Document	T ₀ +12
D2.8.1.3-4.6	Acceptance Test Procedure (ATP)	Document	T ₀ +12
D2.8.1.3-4.7	Digital model of the final 3D arrangement (in CATPart or STEP file) with integration in the available volumes	Document	T ₀ +12
B1 models review and deliveries			
D2.8.1.3-5.1	Acceptance Test Reports (ATR)	Document	T ₀ +18
D2.8.1.3-5.2	First Article Inspection (FAI)	Document	T ₀ +18
D2.8.1.3-5.3	Two B1 models delivery (one for bench and one spare)	Prototypes	T ₀ +18
TRL5 review Documents			
D2.8.1.3-6.1	B1 model test results (e.g. functional and integration) to achieve TRL5	Document	T ₀ +23
D2.8.1.3-6.2	Substantiations + TRL5 form	Document	T ₀ +23
Loop on Critical Design Documents			
D2.8.1.3-7.1	Updated CDR documentation	Document	T ₀ +25
B2 models review and deliveries			
D2.8.1.3-8.1	Acceptance Test Reports (ATR)	Document	T ₀ +28

Ref. No.	Title - Description	Type	Due Date
D2.8.1.3-8.2	First Article Inspection (FAI)	Document	T ₀ +28
D2.8.1.3-8.3	Three B2 models delivery (one for flight, one for bench and one spate)	Prototypes	T ₀ +28
Flight Clearance Tests Documents			
D2.8.1.3-9.1	Qualification Reports (e.g. Environment)	Document	T ₀ +31
D2.8.1.3-9.2	Declaration of Design and performance	Document	T ₀ +31
D2.8.1.3-9.3	Software and Hardware Complex verification results	Document	T ₀ +31
TRL6 review Documents			
D2.8.1.3-10.1	B2 model test results (e.g. qualification) to achieve TRL6	Document	T ₀ +41
D2.8.1.3-10.2	Substantiations + TRL6 form	Document	T ₀ +41
End of Project review – Extrapolation to serial product			
D2.8.1.3-11.1	Final report	Document	T ₀ +42

4.2. Milestones

Ref. No.	Title - Description	Type	Due Date
M2.8.1.3-1	Kick off Meeting	Review	T ₀
M2.8.1.3-2	Progress Report	Report	Every two months from T ₀ to T ₀ +42
M2.8.1.3-3	Specification review	Review	T ₀ +3
M2.8.1.3-4	Preliminary design Review	Review	T ₀ +6
M2.8.1.3-5	Critical Design Review n°1	Review	T ₀ +12
M2.8.1.3-6	M model delivery	Delivery	T ₀ +13
M2.8.1.3-7	First Article Inspection	Delivery	T ₀ +18
M2.8.1.3-8	TRL5 Review	Review	T ₀ +23
M2.8.1.3-10	Critical Design Review 2	Review	T ₀ +25
M2.8.1.3-11	First Article Inspection 2	Review	T ₀ +28
M2.8.1.3-12	Declaration of Design and Performance	Delivery	T ₀ +31
M2.8.1.3-13	TRL6 Review	Milestone	T ₀ +41
M2.8.1.3-15	Extrapolation to serial product Report	Report	T ₀ +42

4.3. General Schedule

	2016		2017				2018				2019				2020	
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
TS 2.8.1.3-1 KOM	▼	KOM														
TS 2.8.1.3-2 Progress Report																
TS 2.8.1.3-3 Specification review		▼	Specification Review													
TS 2.8.1.3-4 Preliminary design			▼	PDR												
TS 2.8.1.3-5 Critical design					▼	CDR1										
TS 2.8.1.3-6 M model manufacturing						▼	M model Delivery									
TS 2.8.1.3-7 B1 model manufacturing							▼	FAI & deliveries: 2B1								
TS 2.8.1.3-8 B1 model tests at partner's bench to validate TRL5								▼	TRL5 Review							
TS 2.8.1.3-9 Integration tests at Customer's bench to validate TRL5									▼							
TS 2.8.1.3-10 Loop on Critical design								▼	CDR2							
TS 2.8.1.3-11 B2 model manufacturing									▼	FAI & deliveries: 3B2						
TS 2.8.1.3-12 Flight Clearance Tests										▼	DDP					
TS 2.8.1.3-13 Flight test campaign																
TS 2.8.1.3-14 TRL6 demonstration															▼	TRL6 Review
TS 2.8.1.3-15 Extrapolation to serial product															▼	Final Report

5. **Special skills, Capabilities, Certification expected from the Applicant(s)**

The applicant must have design and manufacturing capability in electric machine Field.

The applicant shall demonstrate ability to design and manufacture aeronautic equipment, he must show experience in utilization of DO160, DO178, DO254 standards concerning all necessary qualification tests for permit to fly with the helicopter demonstrator.

The applicant must show equivalent activities for airborne equipment in his technical field. Minimum qualification required: ISO9001, EN9100, CS PART21, PART 145 if possible.

The target is to obtain the optimum between the level of performances of the fast rotorcraft and the cost of the potential product.

For the PDR, the Partner will provide an estimation of the recurring cost of the component on the basis of the assumptions given by the Topic Manager. An up-date will be provided for CDR and at the end of the demonstration phase.

Capacity to monitor and decrease the use of hazardous substances regarding REACH regulation

XII. Bird strike - Erosion resistant and fast maintainable windshields

Type of action (RIA or IA)	IA		
Programme Area	FRC (LifeRCraft)		
Joint Technical Programme (JTP) Ref.	FRC2.2 (airframe structure)		
Indicative Funding Topic Value (in k€)	600 k€		
Duration of the action (in Months)	50 months	Indicative Start Date ³⁰	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-FRC-02-14	Bird strike - Erosion resistant and fast maintainable windshields
Short description (3 lines)	
A complete set of lightweight windshields for the Fast Rotorcraft has to be developed, manufactured and tested. This encompasses both sides of the front area as far as the upper pilot- and the lower-windshields. It is an opportunity to develop a lightweight innovative windshield fulfilling the requirement of a non-pressurized high speed rotorcraft aircraft (bird strike resistant, low drag, compatible with water repellent treatment...).	

³⁰ The start date corresponds to actual start date with all legal documents in place.



1. Background

High Speed demonstrator, expanded flight envelope, low drag design, bird strike resistance, enhanced maintainability

The Fast Rotorcraft Project (FRC) aims at demonstrating that the compound rotorcraft configuration implementing and combining cutting-edge technologies as from the current Clean Sky Programme opens up new mobility roles that neither conventional helicopters nor fixed wing aircraft can currently cover in a way sustainable for both the operators and the industry.

The project will ultimately substantiate the possibility to combine in an advanced rotorcraft the high cruise speed, low fuel consumption and gas emission, low community noise impact, and productivity for operators. A large scale flightworthy demonstrator embodying the new European compound rotorcraft architecture will be designed, integrated and flight tested.

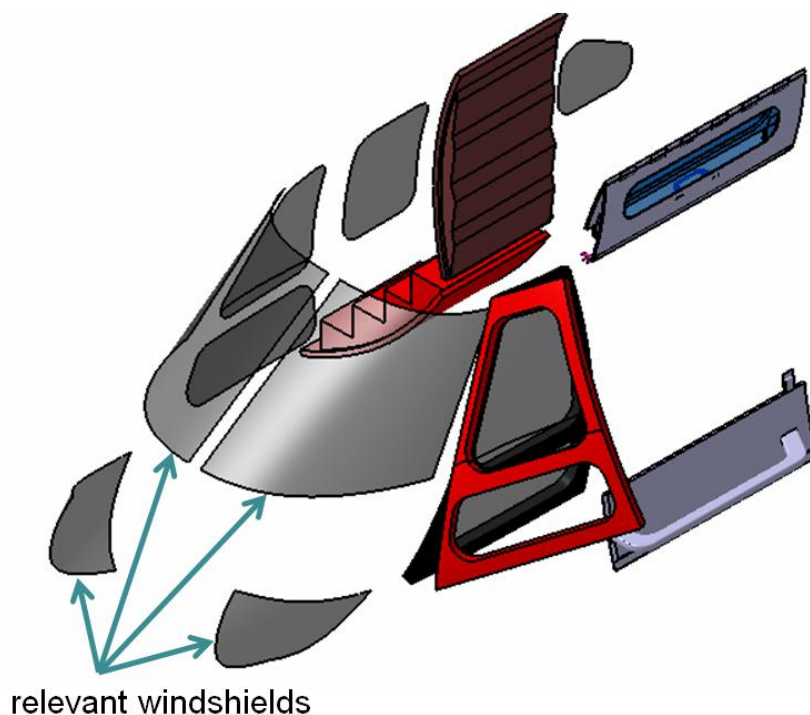
In addition to the complex vehicle configurations, Integrated Technology Demonstrators (ITDs) will accommodate the main relevant technology streams for all air vehicle applications. They allow the maturing of verified and validated technologies from their basic levels to the integration of entire functional systems. They have the ability to cover quite a wide range of technology readiness levels.

2. Scope of work

Innovation target is to achieve a weight reduction of 40% for double-curved bird-strike resistant windshields with included and improved de-fogging and de-icing capability, fast maintainability, long-term scratch resistance with optimal optical quality and compatible with water repellant treatment which will enable to avoid the use of wipers.

Helicopter windshields have to ensure superior optical quality and bird strike resistance (only CS29 types) under all kinds of environmental conditions and operations. Today, these requirements cause tremendous extra cost and weight. For instance: Before take-off, De-Fogging and De-Icing of helicopters is realized by air conditioning that leads to long-time delay and (unnecessary) high fuel consumption. During operation, polymeric windshields suffer under insufficient scratch resistance that causes frequent demand for repair/exchange of windshields by/at the customers. These requirements induce additional weight to recent heavy double curved windshield design granting sufficient bird strike resistance.

The subject of this Call for Partners are all the activities needed for developing and manufacturing the windshields of the LifeRCraft Demonstrator as part of the ITD Airframe for further application and use in the High speed Rotorcraft LifeRCraft IADP. Therefore activities such as engineering activities, manufacture and test are to be performed in this call. In addition to the technical activities the relevant management activities have to be performed also.



Tasks		
Ref. No.	Title – Description	Due Date
1	Development, layout, design and certification of the windshields for a High Speed H/C. Features to be included: • Bird strike resistance according to CS29 • Optimized for Pilot's view capability • Superior optical quality • Scratch/abrasion resistance (also gravel, wisher/wiper) • Light weight design • Easy and fast maintainability and assembly (bonding) • De-fogging capability (coating) • Repellent characteristics • Compatible with electrical anti-icing • Low recurring costs • Media resistance • Noise reduction • HUD compatibility (only for the upper pilot windshields) • Mitigation laser threats The development has to be done in close cooperation with the Topic Manager	T0+21
2	Manufacturing of left and right pilot windshields for test article	T0+20
3	Manufacturing of left and right lower windshields for test article	T0+20
4	Testing of the windshields will comprise e.g. optical quality, scratch resistance, bird strike...	T0+21
5	Delivery of left and right pilot windshields for FRC	T0+22
6	Delivery of left and right lower windshields for FRC	T0+22
7	Support to installation	T0+22
8	Contributing to obtain the permit to flight Contributing to obtain permit to flight documentation for the windows	T0+24
9	Support to flight test campaign	T0+50

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
D1	Concept for windshields (materials, coatings, composite approach, de-fogging, de-icing, etc ...)	Doc	T0+06
D2	Concept for windshields assembly + maintainability	Doc	T0+06
D3	Detailed drawings	Doc	T0+16
D4	Windshields (hardware) for Mock-up	HW	T0+24
D5	Windshields (hardware) for FRC	HW	T0+22
D6	Contributing to "Permit to Fly"	Doc	T0+24
D7	Report about lessons learnt from flight test	Doc	T0+50

Milestones (when appropriate)			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
M1	PDR	MS	T0+06
M2	CDR	MS	T0+18
M3	Flight test survey	MS	T0+50

4. Special skills, Capabilities, Certification expected from the Applicant(s)

The Topic Manager is the responsible in front of the airworthiness agency, and it is therefore mandatory that the Topic Manager will be supported by the Partner with respect to all certification related activities in relation with the windshields. Therefore the Partner has to provide all documentation necessary to achieve “Permit to Fly” and take action allowing this goal to be reached:

- Providing material data which are required to achieve a “Permit to Fly”;
- Using material, processes, tools, calculation tools etc. which are commonly accepted in the aeronautic industry and certification authorities;
- Facilitating harmonization of calculation processes/tools with the Topic Manager;
- Acting interactive with the Topic Manager at any state of work;
- Giving access to the production and test sites;
- Performing the updates of documentation in case of in-sufficient documentation for authorities;
- Checking TRL level 4 is reached for each system/technology upon project start (Q2 2016). Should this condition not be met, the Partner has to provide a mitigation plan enabling to reach the target of TRL 6 at the end of demonstration.

Weight:

The target is obtained the lowest weight as possible for the proposed component compliant with technical requirements and compatible with a serial aeronautical production.

The applicant(s) shall provide an estimated maximum weight of its proposed component. This value will be updated before T0 regarding the design data available at this time, the difference with the weight provided with the offer shall be substantiated and the new weight figure will have to be agreed with the Topic Manager.

For the PDR, the Partner shall a detailed weight breakdown of the component in accordance with the technology, the technical requirement and the interfaces agreed with the leader. The difference with the weight agreed at T0 will be substantiated and submitted to the agreement of the Topic Manager.

For the CDR, the Partner shall provide an update of the weight breakdown with a substantiation of the difference with PDR version. If an update of the overall weight is necessary, it will be submitted to the agreement of the Topic Manager.

The components for the flying demo will be delivered with a weight record sheet, deviation with the maximum weight agreed during CDR will be substantiated.

At the end of the contract, the Partner shall provide a weight estimation of the component for a production part in accordance with the lessons learned during the development.

Recurring cost estimation:

The target is to obtain the optimum between the level of performances of the fast rotorcraft and the cost of the potential product.

For the PDR, the Partner will provide an estimation of the recurring cost of the component on the basis of the assumptions given by the Topic Manager. An up-date will be provided for CDR and at the end of the demonstration phase.

Data management:

The Topic Manager will use the following tools for drawing and data management:

- CATIA V5 R21

- VPM
- Windchill

The Partner will provide interface drawings and 3D model for digital mock-up in CATIA V5 R21. The data necessary for configuration management have to be provided in a format compatible with VPM and Windchill tool.

Eco-design

Capacity of performing Life Cycle Analysis (LCA) to define environmental impact of technologies (energy, VOC, waste, etc) is required from the Partner.

This approach will be integrated during design & manufacturing phases. The Topic Manager will be able support LCA approach (Methodologies training or pilot cases).

Capacity to monitor and decrease the use of hazardous substances e.g. compliant with REACH regulation

Special Skills

Abbreviations: (M) for Mandatory; (A) for Appreciated.

- Experience in design, manufacturing and testing of polymeric transparencies (M).
- Design, analysis and configuration management tools of the aeronautical industry (i.e. CATIA v5 release 21, NASTRAN, VPM) (M).
- Competence in management of complex projects of research and manufacturing technologies(M).
- Experience with TRL Reviews or equivalent technology readiness assessment techniques in research and manufacturing projects for aeronautical industry (M).
- Proven experience in collaborating with reference aeronautical companies with industrial air vehicle developments with “in – flight” components experience (M).
- Capacity to support documentation and means of compliance to achieve experimental prototype “Permit to Fly” with Airworthiness Authorities (i.e. EASA, FAA and any others which may apply) (M).
- Capacity to specify material and structural tests along the design and manufacturing phases of aeronautical components, including: material screening, panel type tests and instrumentation (M).
- Capacity to perform structural and functional tests of aeronautical components: test preparation and analysis of results (M)
- Capacity to repair/rework “in-shop” components due to manufacturing deviations(M).
- Capacity of performing Life Cycle Analysis (LCA) and Life Cycle Cost Analysis (LCCA) of materials and structures (A).
- Capacity of evaluating design solutions and results along the project with respect to Eco-design rules and requirements (A).
- Design Organization Approval (DOA)(M).
- Product Organization Approvals (POA)(M).
- Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004)
- Qualification as Material and Ground Testing Laboratory of reference aeronautical companies (i.e. ISO 17025 and Nadcap)(M).
- Technologies for polymeric material manufacturing (M).
- Mechanical processes, regarding assembly of windshield to surrounding structure (M).

Material and Processes

In order to reach the main goals of the project two major aspects have to be considered for materials and processes, namely : maturity and safety for the project.

Because of the ambitious plan to develop a flying prototype in a short time frame, the manufacturing technology of the partner must be on a high maturity level (TRL4) in order to be able to safely reach the required technology readiness for the flying demonstrator.

To secure this condition, the partner will have to demonstrate the technology readiness for his proposed materials and process and manufacturing technology with a TRL review, to be held together with Topic Manager.

The TRL review must be held within one year after beginning of the project and must confirm a maturity of TRL5 or at least TRL4 if a solid action plan to reach TRL5 within the scope of one further year and finally meet the TRL target for the demonstrator is validated and accepted by AH. Furthermore, since the schedule of the project and the budgetary framework don't allow for larger unanticipated changes in the middle of the project, it is required that at the start of activities the partner demonstrates his capability to develop and manufacture the required items with a baseline technology (which can be e.g. PMMA or PC windshields with established coatings and adhesives as well as screwed windshield frames) which will be a back-up solution if the new technology to be introduced, proves to be overly challenging.

This back-up plan, which shall secure the meeting of the project goals, shall also be agreed between AH and the Partner within half a year after start of the activities and approved by the JU.

Due to the location of the windshields in the front of the H/C special attention should be given to a weight-optimized solution for the windshield materials and the installation concept.

With regards to a potential serial application the RCs (recurring costs) should be taken into consideration through the complete development process starting from the concept phase.

Furthermore all selection of concepts and materials should be made within the framework of an eco-design approach with a special attention to ecological topics.

Furthermore the M&P activities in the ITP shall support the safe inclusion of the partner technology into the complete H/C.

Certification:

- Design Organization Approval (DOA).
- Product Organization Approvals (POA).
- Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004)
- Qualification as Material and Ground Testing Laboratory of reference aeronautical companies (i.e. ISO 17025 and Nadcap).

1.4. Clean Sky 2 – Airframe ITD

I. CROR Engine debris Middle level Impact and mechanical test

Type of action (RIA or IA)	IA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	A-1.2.2		
Indicative Funding Topic Value (in k€)	400 k€		
Duration of the action (in Months)	36 months	Indicative Start Date ³¹	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-AIR-01-08	CROR Engine debris Middle level Impact and mechanical test
Short description (3 lines)	
These work package deals with the development and maturation of innovative shielding able to sustain high and low energy debris associated to the engine failure. The objective of the work is to perform impact and mechanical test on structural and non-structural shielding for aircraft, to sustain high and low energy debris impact.	

³¹ The start date corresponds to actual start date with all legal documents in place.

1. Background

New, eco-efficient aircrafts are challenged by a demand to significantly reduce the CO₂ and NO_x emission. To achieve these goals, the topic manager is exploring new configurations for integrating advanced engines and propulsion concepts to the aircraft. Most of such promising concepts as the CROR-engine, Boundary Ingestion Layer (BIL), Ultra High Bypass Ratio engines (UHBR), multiple fan cannot be targeted simply by replacing engines of the current generation, but require a substantial change of the principle aircraft configuration.

Results from recent research programmes have provided much evidence that many of these concepts do lead to better gains of ecologic and economic efficiency by installing them on the rear end of the fuselage.

The advantage of an installation on the rear fuselage is motivated by the favorable spatial integration conditions in particular for large fan or rotor diameters or multiple fans which can be the key for achieving unprecedented fuel efficiencies. In case of un-ducted engine architecture as the CROR, the rearward shift of the engines away from the wing provides additional advantages in cabin noise and passenger comfort and safety improvement.

Regarding the safety, main issue is the CROR engine debris that can be released with high energy when there is a failure. It is mandatory to develop innovative solutions for panels and shielding able to shield and reduce damage at impact, to secure the airframe integrity, so that aircraft can make safe continuation of flight and landing after engine burst event.

This topic deals with the development and maturation of innovative shielding and structural able to sustain high and low energy debris associated to the engine failure.



Figure 2. R&T concept study with rear mounted open rotor engines

2. Scope of work

The objective of the work is to perform Impact and mechanical test on structural and non-structural shielding for aircraft, to sustain high and low energy debris impact.

Physical test is required to determine that shielding solutions are able to arrest middle representative engine debris, producing no damage or minimum damage to the structure to be protected, with minimum penalty weight.

Applicant is responsible to perform and analyse impact and mechanical test required to validate shielding solutions. The definition and manufacturing of the shielding solutions and the impactors are the scope of other work packages and are not included on the tasks, but interactions and adaptation proposal for such impactors and shielding panels are required to best fit to final test set-up conditions.

There will be two level of validation:

- 1) Level 1. Low representative level for preliminary evaluation and screening of solutions. Flat panels impacted by simplified impactor. See Details described below.
- 2) Level 2. Middle/High representative level for intermediate validation. Curved and/or flat panels with more representative geometry will be impacted with representative composite and metallic impactor . See Details described below.

For both level 1 and 2 the work will be performed by the applicant following the following steps:

1) Test request and test requirement consolidation support. The applicant will support the refinement and consolidation of impact test requirements with topic manager.

2) Test definition support. The applicant will perform preliminary pre-test simulations with impact explicit simulation codes as Abaqus. Results of this simulation will allow refining the test boundary conditions, the best position and number of the sensor as camera and strain gauge, the reaction forces allowing the detail design on the rig, etc... Results and models should be provided to topic manager in Abaqus exploitable format for validation. As results of this virtual test, topic manager will provide consolidated test definition.

4) Test hardware and software definition, materialisation and test performance. Applicant will be responsible to define and materialize all test hardware and software and perform Impact test for both level 1 and 2 according to Test definition and requirements consolidation provided on previous step. Main characteristics and number of impact information for each test level are provided on specific paragraphs bellow.

Test drawing, Rig details, Gas gun performance, test set-up and all Test details will be provided to topic manager for validation previous to manufacturing.

5) Test results report and post-test analysis. Applicant will be in charge of performing test data reduction, analysis and interpretation. Also applicant will perform post-test results correlation by simulation and parametric studies to extrapolate results by simulations, to allow complete test results interpretation.

Simulation models and results including material properties will be provided to topic manager in Abaqus exploitable format for revision and validation.

Main characteristics of level 1 and 2 Test:

Lever 1 Impact test

Impact numbers: up to 250 to 300 panels for 5 structural and 5 non-structural solutions, to determine ballistic limit.

Panel size: Shielding flat panels up to 500x500mm

Panel boundary conditions: simple supported and clamped

Projectile velocity: 60-250m/s

Maximum energy of 20KJ

Two impactor types need to be considered:

Impact test level 1.1:

- Steel ball impactor (30-55mm diameter)

Impact test level 1.2:

- Material: CFRP
- Thickness: 10-20mm
- Length: 150mm
- Width: 40-55mm
- Chamfered

Detail test conditions are orientative and could be adapted by the topic manager on the requirement consolidation phase. Panels could be impacted on several positions if damage generated by the impact is much localised.

Lever 2 Impact test:

Impact numbers: up to 75 to 100 panels for 3 structural and 3 non-structural solutions, to determine ballistic limit.

Panel size: Shielding flat and/or curved panels up to 2mx2m dimensions

Panel simple supported or clamp

Projectile velocity: 60-250m/s

Maximum energy of 200KJ

Two impactor types need to be considered:

Impact test level 2.1:

- Steel segment disc impactor (up to 500 mm diameter approx.)

Impact test level 2.2:

- Material: CFRP blade section(up to 500mm envelope diameter)

Detail test conditions are orientative and could be adapted by the topic manager on the requirement consolidation phase. Panels could be impacted on several positions if damage generated by the impact is very localised.

Additional details for both level1 and 2 tests:

Digital image correlation and several high speed cameras will be required to determine accurately residual velocity after impact, deformation and detail impact behaviour. Also high speed strain gauges will be required to determine the deformation of the impacted materials.

Visual inspection is required for all panels. C-scan will be required on final test samples defining the ballistic limit depending on the final selected material.

Test results, simulation models and simulation results, including material properties will to be provided to topic manager for results validation in Abacus explicit exploitable format.

Depending on the shielding materials finally selected for the level 2, and the maturity of mechanical properties provided by the applicant, the topic manager could request material characterisation test to be performed by the applicant in representative environmental conditions. Objective will be to define accurately the mechanical in plane and out of plane properties to be implemented on the simulation models.

Both impact and mechanical tests need to be performed on representative environmental conditions compared to the real aircraft. In case test conditions cannot fulfil completely required environmental conditions, at least it will be required that the applicant performs additional parametric simulation to demonstrate shielding performance at final environmental condition. Simulations material properties and models according to environmental conditions need to be provided to topic manager in Abaqus exportable format for validation.

Tasks		
Ref. No.	Title - Description	Due Date
T1	Test requirement and definition support (Level 1)	T0+6month
T2	Test definition support and Pre-test simulations (Level 1)	T0+10months
T3	Test drawing and set-up definition (level1)	T0+12months
T4	Test hardware and software realization and Test execution (Level 1)	T0+14months
T5	Test results report (Level 1)	T0+16month
T6	Post-test detailed correlations , analysis and parametric simulations (Level 1)	T0+20month
T7	Test requirement and definition support (Level 2)	T0+16months
T8	Test definition support, Pre-test simulations and mechanical test (Level 2)	T0+20month
T9	Test drawing and set-up definition	T0+22months
T10	Test hardware and software realization and Test execution (Level 2)	T0+26month
T11	Test results report (Level 2)	T0+28month
T12	Post-test detailed correlations , analysis and parametric simulations (Level 2)	T0+36month

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type	Due Date
D1	Test requirement and definition support (Level 1)	Report	T0+6month
D2	Test definition support and Pre-test simulations (Level 1)	Report & simulation models	T0+10months
D3	Test drawing and set-up definition (level 1)	Report, 3D models and drawings	T0+12months
D4	Test hardware and software realization and Test execution (Level 1)	Test hardware & Software	T0+14months
D5	Test results report (Level 1)	Report, Videos, tables and NDT	T0+16month
D6	Post-test detailed correlations , analysis and parametric simulations (Level 1)	Report & simulation models	T0+20month
D7	Test requirement and definition support (Level 2)	Report	T0+16months
D8	Test definition support, Pre-test simulations and mechanical test (Level 2)	Report & simulation models	T0+20month
D9	Test drawing and set-up definition (level 2)	Report, 3D models and drawings	T0+12months
D10	Test hardware and software realization and Test execution (Level 2)	Test hardware & Software	T0+24month
D11	Test results report (Level 2)	Report, Videos, tables and NDT	T0+26month
D12	Post test detailed correlations , analysis and parametric simulations (Level 2)	Report & simulation models	T0+36month

Milestones		
Ref. No.	Title - Description	Due Date
M1	Test requirement (Level 1)	T0+6month
M2	PRM. Test definition support and Pre-test simulations (Level 1)	T0+10months
M3	TRM. Test drawing and set-up definition (level 1)	T0+12months
M4	Test Execution. Test hardware and software realization and Test execution (Level 1)	T0+14months
M5	Test results report (Level 1)	T0+16month
M6	Post- test detailed correlations , analysis and parametric simulations (Level 1)	T0+20month

Milestones		
Ref. No.	Title - Description	Due Date
M7	Test requirement (Level 2)	T0+16months
M8	PRM. Test definition support and Pre-test simulations. Mechanical test results (Level 2)	T0+20month
M9	TRM. Test drawing and set-up definition (level 2)	T0+12months
M10	Test Execution. Test hardware and software realization and Test execution (Level 2)	T0+24month
M11	Test results report (Level 2)	T0+26month
M12	Post test detailed correlations , analysis and parametric simulations (Level 2)	T0+36month

4. Special skills, Capabilities, Certification expected from the Applicant

SKILLS, CAPABILITIES GENERAL

- The applicant (s) will have the capacity and resources in house (instrumentation, data acquisition, test recording (high speed cameras), 3D correlation systems and analysis) to perform high velocity impact testing.
- The applicant (s) will have a background in:
 - FEM structural analysis and 3D modeling,
 - determining requirements for development of structural test in Research and Technology (R&T) activities for aeronautics
 - research and Technology (R&T) projects cooperating with industrial partners, institutions, technology centers, universities and lessons learnt achievements in the frame of R&T European Programs (FP7, H2020).

RELATIVE TO EXPERIMENTAL

- The applicant (s) shall demonstrate consolidated experience in:
 - design, development and set up of gas cannons,
 - adapt and assemble devices and tools (sabots, restraints systems, quick response compressed air gate valves and support rigs), needed to prepare and perform different types of high velocity impact testing,
 - analysis of high speed impact phenomena.
- The applicant(s) shall be able to demonstrate sound technical knowledge in:
 - developing complex experimental set-up for high velocity impact tests,
 - using high speed data acquisition systems and high speed cameras,
 - developing instrumentation procedures for high velocity impact tests,
 - developing sabots to impel complex geometries,
 - setting-up large launchers to impel large impactors with complex geometries,
 - using high speed three dimensional correlation systems
- The applicant (s) shall have or be able to have:
 - facilities able to carry out impact tests on full scale specimens.
 - a launcher facility (to be used in the experimental tests), with a caliber of at least 500 mm, and capable to reach velocities up to 250 m/s.

RELATIVE TO NUMERICAL

- The applicant(s) shall be able to demonstrate sound technical knowledge in
 - use and development of impact simulations using explicit solvers (Abaqus, LS-dyna),
 - developing constitutive models of both metal and composite materials at high strain rates,
 - developing user materials subroutines in different commercial finite element codes (Abaqus, LS-dyna),
 - translation of different models from other software to Abaqus explicit,

- correlation complex experimental test with numerical simulations for blade impactors and other high energy similar impactors (Bird impact, crash impact, etc...) up to full scale.

II. Experimental characterization of turbulent pressure fluctuations on realistic Contra-Rotating Open Rotor (CROR) 2D airfoil in representative high subsonic Mach number.

Type of action (RIA or IA)	IA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	A-WP1.2.2		
Indicative Funding Topic Value (in k€)	400 k€		
Duration of the action (in Months)	12 months	Indicative Start Date³²	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-AIR-01-09	Experimental characterization of turbulent pressure fluctuations on realistic Contra-Rotating Open Rotor (CROR) 2D airfoil in representative high subsonic Mach number.
Short description (3 lines)	
The prediction of Open Rotor broadband noise requires boundary layer turbulence statistics that are not available today in the literature at the high subsonic relative Mach number encountered by the blades. High fidelity wind tunnel tests shall be performed to fill this lack.	

³² The start date corresponds to actual start date with all legal documents in place.

1. Background

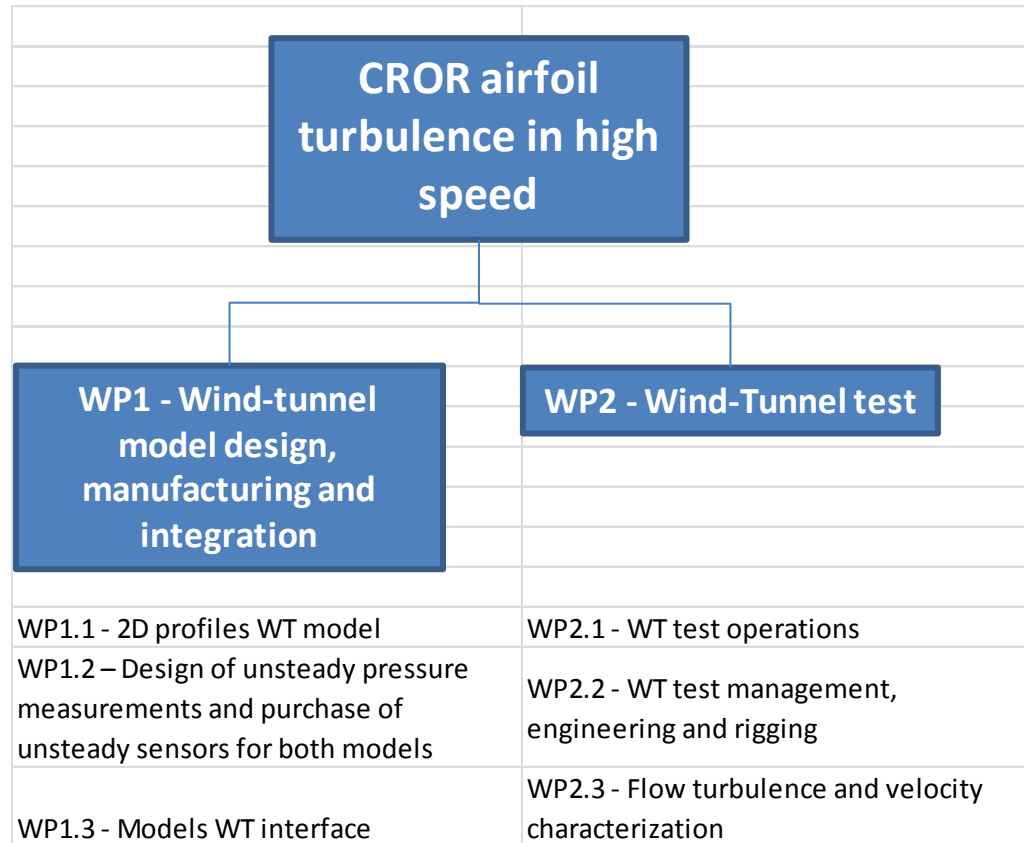
Over the last decades, major research efforts succeeded in drastically reducing the strong tonal noise of Contra-Rotating Open Rotor engines (CROR) thanks to extensive testing and development of advanced modelling methods. Now, the broadband noise becomes a significant part of the emitted noise, while limited research efforts were put on its prediction. The prediction methods show indeed today a rather low maturity level, so that dedicated tests and modelling actions are necessary to bring the prediction tools to the same maturity level as their counterpart on tonal noise.

One of the major sources of broadband noise is due to the deformation of the turbulent vortices contained in the rotor blade boundary layer when they pass over the trailing edge. An analytical model was already developed to predict the emission of this noise source. It has to be fed by statistics of the surface pressure turbulent fluctuations close to the trailing edge, namely the fluctuation spectrum, the convection velocity and the spanwise correlation length of the blade surface pressure. A number of experiments were conducted since the 70s on flat plates, NACA profiles and other profiles to establish reference data for those statistics, but they were all done at rather low Mach numbers around 0.2 or below. No experimental data nor high fidelity simulations are available for the high subsonic Mach numbers encountered by the rotor blades operating in approach (0.5), take-off (0.7) and cruise (0.9) conditions, and the shortfall of the analytical method in comparison to open rotor experimental data is thought to be mainly due to the use of the low Mach number literature data on profiles too much different from CROR blade profiles.

The objective of this work is to fill this lack by conducting a wind tunnel test (WTT) on a CROR representative 2D airfoil at high rotating speeds (Mach number 0.5 to 0.7) with heavy instrumentation close to trailing edge. It shall provide the information required by the broadband noise analytical models but also constitute a high quality database for future high fidelity numerical computation (not included in this CfP).

It shall also be noted that this data will also be of high value for the modelling of fan broadband noise.

The WBS is as followed:



2. Scope of work

The objective of the work is to perform the Design, Manufacture and test in high speed condition of a 2D airfoil with a surface pressure chordwise distribution representative of a CROR blade under representative high subsonic relative Mach numbers. The applicant will use advanced measurement techniques for deep characterisation of the profile's boundary layer and wake in order to establish reference data for broadband noise prediction tool calibration.

Tasks		
Ref. No.	Title – Description	Due Date
WP1	Wind-tunnel model design, manufacturing and integration	
WP1.1	2D profiles WT model	T0+6months
WP1.2	<u>Design of unsteady pressure measurements</u> and purchase of unsteady sensors for both models	T0+2months
WP1.3	Models WT interface	T0+6months
WP2	Wind-Tunnel test	
WP2.1	WT test operations	T0+8months
WP2.2	WT test management, engineering and rigging	T0+12months
WP2.3	Flow turbulence and velocity characterization	T0+12months

WP1 - Wind-tunnel model design, manufacturing and integration

WP1.1 - 2D profiles WT model

In this task, the applicant will design and manufacture two 2D airfoil profiles.

- The first will be aerodynamically designed by the applicant to obtain a pressure distribution representative of the pressure distribution of a CROR front blade section at 75% of blade span in take off condition
- The second will be representative of a well known profile like a NACA0012 to be defined at T0.

The pressure distribution target and the geometries of CROR reference airfoil and of the well known profile will be provided by the topic manager. The aerodynamic and structural designs will be shared with and validated by the topic manager.

This task includes the integration of unsteady sensors purchased in the task WP1.2, of the static pressure (about 50 by profile) and of specific instrumentation as boundary layer rakes to be placed close the the trailing edge.

The conditions of testing are defined below in WP2.1 for the structural justification.

A chord length of about 30 cm (representative of full scale blade chord) shall be targeted. Chord/span ratio shall be defined in order to avoid significant side wall effect on the CP distribution and turbulence statistics in the airfoil mid-span region where the instrumentation will be installed. An aerodynamic justification is requested and to be validated by the topic manager. Should the test facility of the applicant not be sufficiently large to test a 30cm span without avoiding side wall effect,

a lower chord may be proposed by the applicant with a proposal on how to extrapolate the data to higher Reynolds numbers.

WP1.2 – Design of unsteady pressure measurements and purchase of unsteady sensors for both models

In this task the applicant will design the unsteady pressure measurements convenient for the following specification and select the appropriate sensors. The choice will be validated by the topic manager. Once the choice is validated, the applicant will purchase these sensors, if not available, and the associated material for their integration planned in WP1.1. This task shall be done in close collaboration with WP1.1.

The unsteady pressure measurements shall be designed for the following requirements:

- They shall be located close to trailing edge
- A study shall be conducted to select between blade surface microphones, deported microphones and kulite sensors with the objective of maximizing the number of sensors while ensuring a high quality of surface pressure turbulence statistics measurements (fluctuation spectrum, convection velocity and correlation lengths)
- Maximum frequency : about 15.000Hz for a 30cm chord (final value to be defined by the topic manager depending of the selected airfoil chord)
- Number of sensors: about 30 per profile
- One chordwise line terminating as close as possible to trailing edge (target 98% chord)
- One spanwise line as close as possible to trailing edge (target 98% chord)

WP1.3 - Models WT interface

This task deals with the design and manufacturing of interface between WT models defined in WP1.1 and the WT selected in the task WP2.1. It will allow incidence change in continuous and pitch pause in the incidence range defined in WP2.1. It will allow the safe routing of the instrumentation from the model to the WT data acquisition system.

WP2 - Wind-Tunnel test

WP2.1 - WT test operations

This WP deals with the WT test operation in following conditions:

- Mach numbers 0.2 (Literature reference) / 0.5 (approach)/ 0.7 (Take-off)
- Atmospheric conditions
- Variation of incidence: -10° / +10°
- Possibility to perform acoustic measurements of the trailing edge noise is not mandatory but may be an advantage for the proposal.
- Allows WP2.3 task

The applicant shall demonstrate in his proposal that the surface pressure measurements will not be

polluted by spurious noise of the proposed test facility, especially in the case of a closed wind tunnel. Also, should the test facility of the applicant not reach the target Mach number 0.7, a minimum of Mach number 0.5 is required, and a process to extrapolate data up to higher Mach numbers shall be proposed. This extrapolation is not required to be part of this project if requiring heavy numerical computations. This lower Mach number may be justified to ensure high quality surface pressure measurements. The quality of the unsteady pressure measurements (that should be polluted as low as possible by the test facility) is of higher priority than reaching the target 0.7 Mach number.

5 productive testing days are expected.

If easily possible, the model forces and moments shall be measured.

This task includes the data acquisition and delivery of data from instrumentation defined in WP1.1 and WP1.2. The expected data format will be defined by the topic manager.

WP2.2 - WT test management, engineering and rigging

This task includes management of the project, engineering for the design, manufacturing and testing, as well as operations to be carried out on the model during WT test (configuration change for example).

WP2.3 - Flow turbulence and velocity characterization

PIV and/or hotwire solutions are expected to be installed and operated by the applicant in WT selected in WP2.1, for measurements in vicinity of the trailing edge, either the boundary layer or the near wake to ensure the best accuracy. It shall provide 3-component turbulent velocity statistics (at a minimum Reynolds stress tensor and 2-point spatial correlations). It includes the post processing and the data delivery (format to be defined by the topic manager).

Detailed requirements for those measurements (e.g. spatial resolution) shall be agreed with the topic manager.

Also, post-processing and analysis of the unsteady surface pressure measurements shall be conducted by the applicant to provide surface pressure spectra, convection velocities and integral length scales.

3. Major deliverables/ Milestones and schedule (estimate)

Tasks	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12
WP1 - Wind-tunnel model design, manufacturing and integration												
WP1.1 - 2D profiles WT model												
WP1.2 – Design of unsteady pressure measurements and purchase of unsteady sensors for both models												
WP1.3 - Models WT interface												
WP2 - Wind-Tunnel test												
WP2.1 - WT test operations												
WP2.2 - WT test management, engineering and rigging												
WP2.3 - Flow turbulence and velocity characterization												
TRL3												
TRL4												
TRL5												
TRL6												

Deliverables			
Ref. No.	Title – Description	Type	Due Date
D1.1.1	Profile aerodynamic design		T0+2months
D1.1.2	WT model design		T0+4months
D1.1.3	Chord /span aerodynamic justification		T0+4months
D1.2	Unsteady sensor selection		T0+2months
D2	Data including PIV or hotwire		T0+12months

Milestones (when appropriate)			
Ref. No.	Title - Description	Type	Due Date
TRL3	Preliminary design review	TRL3	T0+2months
TRL4	Critical Design review	TRL4	T0+4months
TRL5	Test Readiness Review	TRL5	T0+6months
TRL6	Data Delivery	TRL6	T0+12months

4. Special skills, Capabilities, Certification expected from the Applicant(s)

Demonstrated capabilities in:

- Aerodynamic design
- WT highly instrumented model design and manufacturing
- WT management and operations
- Flow turbulence and characterization in WT

As these skills are highly specialized it is suggested if relevant that the applicant can be a consortium of several companies offering each of them the best skills to contribute.

III. Erosion-resistant functional coatings

Type of action (RIA or IA)	RIA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	A-2.2		
Indicative Funding Topic Value (in k€)	200 k€		
Duration of the action (in Months)	36 months	Indicative Start Date ³³	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-AIR-01-10	Erosion-resistant functional coatings
Short description (3 lines)	
The objective of this work is to define, demonstrate and apply hard erosion-resistant functional coatings on carbon fiber/epoxy test panels representing a multifunctional Natural Laminar Flow (NLF) wing skin. The applicant is responsible for testing of coating-to-panel adhesion and other basic characterization according to a test plan to be provided by the Topic Manager.	

³³ The start date corresponds to actual start date with all legal documents in place.

1. Background

This topic is part of Airframe High Performance and Energy Efficiency (Activity Line A), Technology stream A-2, Advanced Laminarity. It is part of Work Package A-2.2: Natural Laminar Flow Smart Integrated Wing.

The first necessary condition for a NLF aerodynamic surface, such as a wing panel, is that the surface characteristics promote natural laminar flow. This means that steps, gaps and surface imperfections, e.g. due to through-thickness mechanical fasteners, are non-existent or kept very small. The design and manufacturing technology for a NLF composite wing panel with such high requirements on the aerodynamic surface has been developed and demonstrated in Clean Sky 1.

In addition to surface smoothness and other geometrical surface conditions that promote natural laminar flow, the requirements on a NLF wing panel also include other functions that are critical to the overall performance of the wing and the platform. These additional functions include - but are not limited to- erosion resistance, especially in the wing leading edge area, lightning strike protection, de-icing and anti-icing.

It is important that the use of functional coating(s) on a NLF aerodynamic surface does not deteriorate the surface characteristics necessary for promoting natural laminar flow. If possible, coating characteristics should actually improve the NLF performance of the coated wing. Also, functional coating should be durable, light-weight, cost-efficient and repairable as well as replaceable, when this is relevant. All coating characteristics that improve the overall performance of the coated aerodynamic surface under all operational conditions are desirable.

For a multifunctional NLF wing, there is a need for erosion-resistant functional coatings with electrical conductivity ranging from highly insulating to highly conductive.

The objective of this topic is to tailor existing coating technologies, e.g. based on physical vapour deposition (PVD), to specific Clean Sky 2 requirements, apply the coatings on a large number of small to medium sized test objects and to demonstrate selected coatings regarding their functional properties as well as application method. The demonstration of the application method should be a proof-of-concept, small to medium scale demonstration focusing on technical solutions suitable for further industrialization and scale-up to commercial wing panel size. It shall be carried out on both flat and curved panels representing NLF wing panels.



Figure 1. Clean Sky test object representing NLF integrated wing panel.

2. Scope of work

Tasks		
Ref. No.	Title – Description	Due Date
Task 1	Specification of candidate materials and processes for three NLF wing panel erosion-resistant coating technologies based on physical vapour deposition or a similar process tailored for - Electrically conductive erosion-resistant coating - Electrically resistive erosion-resistant coating (de-icing) - Non-conductive erosion-resistant coating (insulating) This task will be carried out in close collaboration with the Topic Manager	T0+6
Task 2	Preliminary development of material- and process technology for a first set of coated panels using at least three candidate coatings, including small-scale demonstration of a scalable application method on flat composite panels. The number of candidate coatings (at least one per application) will be agreed with the Topic Manager, based on available data on potential candidates.	T0+12
Task 3	Characterization and testing of at least three candidate coating technologies	T0+18
Task 4	Final development of material- and process technology for second set of coated panels using three selected coatings	T0+24
Task 5	Final characterization and testing of three selected coating technologies, including proof-of-concept demonstration of a scalable application method on medium-sized curved composite panels	T0+33

This topic is limited to the definition, application and testing of erosion-resistant electrical function coatings on specially prepared flat and curved composite panels representing a NLF wing skin. The design, manufacturing and initial surface preparation of the composite panels is not included in the task, since test panels will be provided by the Topic Manager. In case a special surface preparation of composite panels is needed for a specific coating solution, this surface preparation must be included in the task.

The test panels will typically be manufactured from a laid-up arrangement of unidirectional carbon fibers pre-impregnated with epoxy (prepreg tape) and autoclave cured at 180° C.

It is very important that the coating technologies are compatible with the carbon fiber/epoxy composite panels to be provided by the Topic Manager. Compatibility issues include, but are not limited to

- Rain erosion protection functionality when applied to a composite panel with an out-of-plane elastic modulus of approximately 10 GPa
- Coating to panel adhesion during and after environmental cycling representing operational conditions, including thermal cycling
- Coating to panel adhesion during and after mechanical cycling (applied strain) representing operational conditions

- Sufficient open area (uncoated area or permeable coating) to allow moisture absorption and desorption during typical operational conditions
- Galvanic corrosion
- Optical properties

Task 1 - Specification of candidate coating materials and processes

The purpose of this task is to specify candidate coating technologies based on the required and preferred functionality of the coating when applied to a NLF wing skin panel. This will be carried out in close collaboration between the applicant and the Topic Manager.

The specification shall include a first definition of suitable industrial method of application, taking into account all relevant aspects of pre-treating large curved composite panels, e.g. size, thermal limitations, pre-treatment and durability during wing box assembly.

Based on Topic Manager previous experience, a PVD process is preferred, but other processes can be included if sufficient data in support of non-PVD processes is provided by the applicant.

Preferably, the applied coating may be used for a number of sensing needs, e.g. for in-flight measurement of aerodynamic pressure and icing conditions. The specification of candidate materials and processes should include all relevant information to allow for improved coating functionality.

Candidate coatings may be hydrophobic or hydrophilic.

Task 2 - Preliminary development of material- and process technology for first set of coated panels

The task includes the first adaption of existing coating materials and processes to the aeronautical requirements relevant for erosion-resistant electrical function coatings. The purpose of this task is to apply candidate coatings on composite panels provided by the Topic Manager. A number of these coated panels will be designed for the Topic Manager specific testing needs, e.g. rain erosion resistance and de-icing/anti-icing functionality. A small-scale demonstration of a scalable process for coating application on flat panels is included in this task.

Task 3 - Characterization and testing of at least three candidate coating technologies

The overall test plan for activities to be carried out by the applicant will be defined by the applicant and Topic Manager in collaboration. It will be coordinated with test activities to be carried out by the Topic Manager, e.g. rain erosion resistance and de-icing/anti-icing tests.

Task 4 - Final development of material- and process technology for second set of coated panels

Following down-selection of candidate coatings based on task 3 results, the selected coatings will be further developed for the intended aeronautical use in this task. This includes a more industrial approach to coating application, including application on composite panels with a representative curvature for wing skins with an integrated leading edge. The purpose of this task is to apply selected coatings on composite panels provided by the Topic Manager. Again, a number of these coated panels will be designed for the Topic Manager specific testing needs, e.g. a more specific set of rain erosion resistance tests, including curved panels and wing-like panels for ice-wind tunnel testing of

de-icing/anti-icing functionality. A medium-scale demonstration of a scalable process for coating application on curved panels is included in this task.

Task 5 - Final characterization and testing of three selected coating technologies

Based on the status of coating development in tasks 1 through 4, the task 5 test plan for activities to be carried out by the applicant will be defined by the applicant and Topic Manager in collaboration. It will be coordinated with test activities to be carried out by the Topic Manager, e.g. rain erosion resistance, de-icing/anti-icing tests and specific electrical function tests as well as assembly of coated test objects designed for demonstration of compatibility with current aerospace manufacturing standards. This demonstration of compatibility includes painting of coated panels.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
D1	Specification of candidate coating materials and processes	Report	T0+6
D2	Report of preliminary developments for material- and process technology for erosion-resistant coatings	Report	T0+12
D3	Coated panels (preliminary coating definition) for Topic Manager testing (e.g. rain erosion)	Coated panels	T0+12
D4	Description of the characterization and testing of candidate coating technologies	Report	T0+18
D5	Final development of material- and process technology for erosion-resistant coatings	Report	T0+24
D6	Coated panels (final coating definition) for Topic Manager testing	Coated panels	T0+24
D7	Description of the characterization and testing of selected coating technologies	Report	T0+34

Milestones (when appropriate)			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
M1	Specification of candidate coatings		T0+6
M2	Review and down-selection of candidate coatings		T0+19
M3	Review of selected coatings and demonstration of application method		T0+36

4. Special skills, Capabilities, Certification expected from the Applicant(s)

Special skills:

The applicant must be able to deliver a complete coating application process at the end of the project. This implies that the applicant must be on a high maturity level and have extensive documented experience from previous research on functional coatings.

The topic will be executed in close collaboration with the Topic Manager and previous experience from joint development with aerospace companies is a major advantage.

Specifically, the applicant should have

- a thorough understanding and demonstrated competence in the area of materials and processes for PVD and similar or related coating technologies
- previous experience from application of coatings on carbon fiber/epoxy panels
- a demonstrated ability to protect new intellectual property and avoid conflict with existing IPR
- a demonstrated ability to industrialize developed technology related to coatings
- previous experience from collaborative R&D of coating technologies, preferably within European projects

IV. High accuracy and low intrusiveness in-flight wing shape and temperature measurements

Type of action (RIA or IA)	RIA		
Programme Area	ITD Airframe		
Joint Technical Programme (JTP) Ref.	A-2.2		
Indicative Funding Topic Value (in k€)	550 k€		
Duration of the action (in Months)	24 months	Indicative Start Date ³⁴	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-AIR-01-11	High accuracy and low intrusiveness in-flight wing shape and temperature measurements
Short description (3 lines)	
Detailed and high accuracy (approximately 20 µm) measurement of aerodynamic surface shapes is a key enabler for the future of laminar flow aerodynamics. The objective of this topic is to develop an integrated and unobtrusive measurement system providing local and global wing structural deformation and temperature data with high environmental constraints.	

³⁴ The start date corresponds to actual start date with all legal documents in place.

1. Background

The perfect knowledge of the shape of an aircraft wing is a key element for an aircraft manufacturer to validate its models and improve the airplane.

The aim of the measuring device to be developed is to measure with a high accuracy both local and global deformations of a Natural Laminar Flow (NLF) wing in flight with reduced impacts on the Flight Test Installation (FTI) in the aircraft.

The measuring system shall be of a very low intrusiveness in order to make possible integration in or on the surface coating of the wing (internal or external) without disturbing the air flow in case of an external integration.

The measuring system shall provide quantitative information on:

- Deformation
- Stress
- Temperature

Any technology fulfilling the below requirements can be proposed. For instance technologies based on optical fibres seem a good candidate with regards to:

- The low weight / volume / power consumption of the equipment,
- The low complexity of the installation, configuration, FTI verification and validation (V&V) efforts.

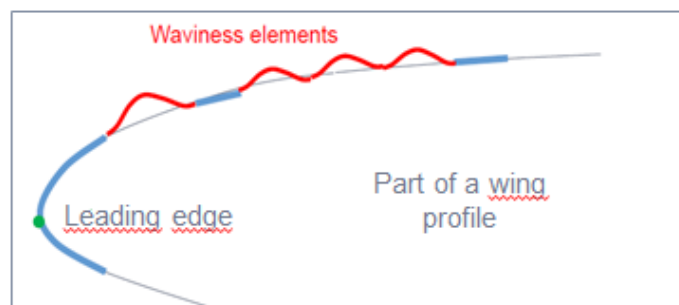
- Two levels of measurements are expected: local and global wing deformations. The priority is given to local deformation measurements due to their particular impact on laminar flow wing and the lack of existing measuring system.

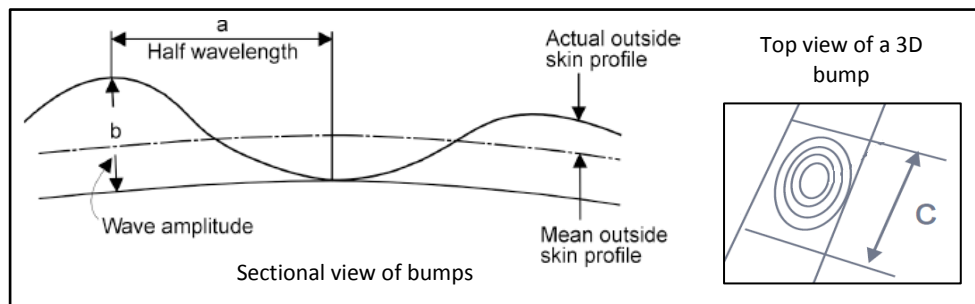
1. Local wing deformation (First Priority)

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

It is therefore of a valuable interest to measure with a very high accuracy the small deformations produced on the wing skin on both the leading edge and the wing upper cover.

Typical waviness or 3D bumps on a wing are specified here after:





with:

- b : wave amplitude
- a : half wavelength in chordwise direction
- b/a : mean slope
- c : wavelength in spanwise direction

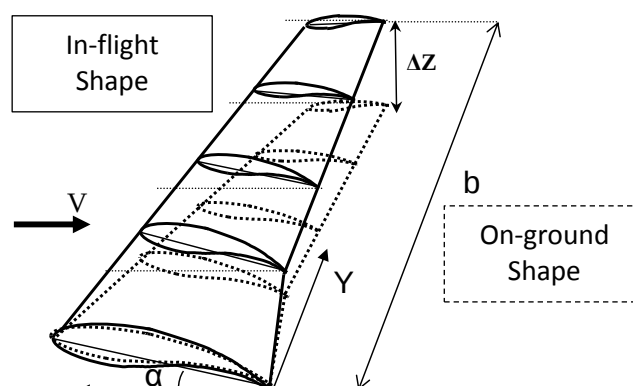
Typical requested measurements:

- Range of parameters:
 - $a \cong 100$ to 600 mm
 - $0.25 \text{ mm} < b < 2.4 \text{ mm}$
 - $c \cong 400$ to 700 mm
- Expected accuracy: 10 to $20 \mu\text{m}$
- Single and multiple waves
- Static or quasi static flight phases only

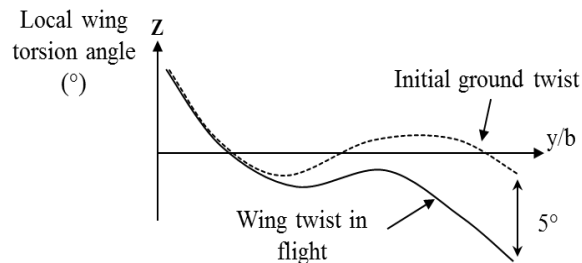
2. Global wing deformations (Second Priority)

The wing shape is designed to achieve the best performances during cruise phases. As the wings are flexible, deformations occur from a ground to a flight position.

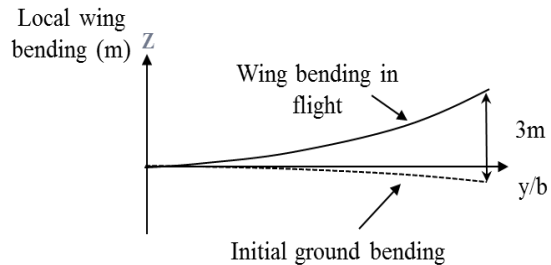
The aim is to measure the twist angles, bending angles and displacements due to these deformations with a high accuracy in static and dynamic flight phases.



Theoretical twist distribution along wingspan



Theoretical bending distribution along wingspan



Typical requested measurements:

- Range of parameters:
 - o Twist and bending angles: -10° to $+10^\circ$
 - o Vertical bending displacements (ΔZ): -500mm to 3500mm
 - o Half wingspan (b): up to 40m
- Expected accuracy:
 - o Twist and bending angles: $<0.1^\circ$ on the full wing span
 - o Vertical bending displacements: <50 mm at wing tip

➤ Specifications: The system shall fulfil the following requirements:

- DO160 (Environmental Conditions and test Procedures for Airborne Equipment) compliant
- Use in A/C harsh environment (temperature, pressure, humidity, UV, EMC...)
- Typical operating temperature range: -55°C to 85°C
- Temporal variation of temperature: $10^\circ\text{C}/\text{min}$
- Temperature variation on same chord at same time: $\sim 10^\circ\text{C}$
- Ideally ATEX compliant (EU guidelines for Explosive Atmosphere)
- Low power consumption
- No optical access necessary (so no camera based technique)
- Possible integration:
 - o Inside the wing, on the inner side of the wing upper cover.
 - o Or outside the wing on top of the paint. The thickness shall be less than 1 mm.
 - o Or outside the wing with ideally an integration inside the topcoat layer for a perfect aerodynamic integration
- Quasi static measurements (typical cut-off frequency about 100 Hz).

➤ Level of Maturity

The aim is to start at TRL 3 minimum and move to TRL 5 in 18 months.

Evidence of TRL3/4 maturity set out in the proposal will be well appreciated.

Opportunities will be offered to the applicant at about M0+18 months to test the demonstrator on a representative on-ground bench to pass TRL 5 then to validate the final system in flight by T0+24 months to reach TRL 6.

2. Scope of work

Tasks		
Ref. No.	Title – Description(with responsibility 100% on applicant side in the absence of any specific comment)	Due Date
TSK 1	Complete and detailed specification of the measuring system	M0 + 2 M
TSK 2	Feasibility study and preliminary laboratory demonstration at sub component level	M0 + 3 M
TSK 3	Definition of a first architecture concept	M0 + 4 M
TSK 4	Design and manufacturing of the first prototype of the system, including data acquisition part + development of specific software	M0 + 8 M
TSK 5	Laboratory metrological tests	M0 + 10 M
TSK 6	Optimization of the architecture and lay-out of the system	M0 + 11 M
TSK 7	2nd prototype of a flight worthy system	M0 + 12 M
TSK 8	Proof of operation through on-ground tests representative of in-flight environment (temperatures, vibrations, ...)	M0 + 13 M
TSK 9	Manufacturing and delivery of the final measuring system (including acquisition part) and associated documentation for installation and operation. This system shall be operable on ground and in flight.	M0 + 14 M
TSK 10	Installation or support for installation on the wing of the test bench	M0 + 14 M
TSK 11	Data acquisition, processing, validation and delivery of results (ground tests)	M0 + 18 M
TSK 12	Technical support during flight test campaign (installation of the device in the A/C and operation of the system during flight out of the responsibility of the applicant) and processing of flight test Data	M0 + 24 M

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
DEL 1	Complete specification - Synthesis of the requirements and ways to reach the objectives	Report	M0 + 2 M
DEL 2	Feasibility Study and Demonstration at subcomponent level	Report	M0 + 3 M
DEL 3	Architecture of the prototype	Report	M0 + 4 M
DEL 4	Prototype for ground test	Product	M0 + 8 M
DEL 5	Metrological test report	Report	M0 + 10 M
DEL 6	Installation guide - Procedure of installation on aircraft	Report	M0 + 10 M
DEL 7	Environmental test report	Report	M0 + 13 M
DEL 8	In-flight Prototype - Final prototype to be tested on wing test bench	Product	M0 + 14 M
DEL 9	Final on-ground validation test (wing bending test)	Report	M0 + 18 M
DEL 10	Complete project technical documentation	Report	M0 + 18 M
DEL 11	In-flight measurement final report	Report	M0 + 24 M

Milestones (when appropriate)			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
MIL 1	Complete specification	Report	M0 + 2 M
MIL 2	Feasability study based on preliminary tests and demonstrators	Report	M0 + 3 M
MIL 3	On-ground tests of the 1 st Prototype	Test	M0 + 10 M
MIL 4	System validation through wing bending test and environmental test	Test	M0 + 18 M
MIL 5	In-flight test of the final prototype	Test	M0 + 24 M

4. Special skills, Capabilities, Certification expected from the Applicant(s)

The applicant(s) shall be an accredited sensor developer and shall have an expertise in:

- Optical fibre component design and development
- Mechanical & system integration studies
- Mathematical models applied to deformation measurement techniques
- Lay-out of measurement equipment for flight testing
- Lab testing for harsh environment conditions measurements
- Ideally flight test instrumentation and installation experience

V. Tool-Part-Interaction simulation process linked to laminate quality

Type of action (RIA or IA)	RIA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	A-3.1		
Indicative Funding Topic Value (in k€)	350 k€		
Duration of the action (in Months)	36 months	Indicative Start Date ³⁵	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-AIR-01-12	Tool-Part-Interaction simulation process linked to laminate quality
Short description (3 lines)	
Highly integrated composite structures require complex tooling with increasing physical and geometrical complexity. Factors affecting laminate quality include thermal expansion, pressure distribution, frictional effects, and their influence on the consolidation of the part. The objective of this topic is to develop a FE based model, currently not available on the market that will make it possible to simulate the complex consolidation process during the cure phase and link the result to laminate quality.	

³⁵ The start date corresponds to actual start date with all legal documents in place.

1. Background

This topic is part of Airframe High Performance and Energy Efficiency (Activity Line A). The topic is one of the key research activities which will ultimately result in the demonstration of an innovative integrated composite wing structure. This topic is part of Work Package A-3.1: Multidisciplinary wing for high and low speed.

Control surface structures are an essential part of a wing, one control surface which will be an area for research/development in Clean Sky 2 is a highly integrated composite aileron for a large passenger aircraft.

Composite ailerons traditionally have a “black-metal-design” with a low complexity of composite parts manufactured individually and later fastened together in an assembly process. Composite parts of lower complexity usually require relatively simple manufacturing tooling’s which have been evolutionally developed during a long period of time by tool designers using robust “rule-of-thumb” methods and guidelines. To be able to save weight and reduce recurring manufacturing costs new more innovative and integrated composite designs with higher levels of complexity have begun to enter the market. Figure 1 illustrates an integrated composite structure.

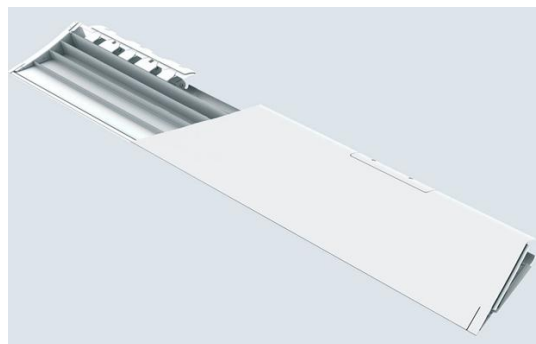


Figure 1. Integrated Aileron composite box. Part of the upper skin is faded out to visualize the internal multispar structure. Upper skin, lower skin and internal spars are co-cured.

A competitive “Time to Market” is a challenge for large integrated complex composite parts. Increased tooling size and complexity drives cost and lead time for the tool set. It is therefore essential to test and verify the tooling concept early in the design process. Late tooling change increases the costs exponentially, delays the start of production and could jeopardise the potential benefits with highly integrated composite parts. To reduce project risks and freeze the tooling concept earlier in the design process a more fundamental approach is required based on processing science, virtual methods and FE-simulations. The approach should to be similar to the methodology used for stress analysis where “trial and error” is not acceptable.

The complex manufacturing process for the Clean Sky 2 aileron demonstrator increases the physical and geometrical complexity of the problem to be modelled. For instance, considering the complex tooling, there is an evident challenge to model all the tooling sub-parts, the interaction between them, including thermal expansion, pressure distribution, frictional effects, and their influence on the consolidation of the part, see Figure 2. The objective of this topic is to develop and validate FE software that will simulate the complex consolidation process during the cure phase and link the

result to laminate quality.

2. Scope of work

Tasks		
<i>Ref. No.</i>	<i>Title – Description</i>	<i>Due Date</i>
Task 1	Specification of process simulation tool(s) for consolidation of highly integrated prepreg parts	T0+6
Task 2	Implementation of process simulation tool(s) in ABAQUS	T0+24
Task 3	Validation of process simulation software	T0+36

This topic is limited to the consolidation of unidirectional carbon pre impregnated with epoxy (prepreg tape) for cure at 180° C in an autoclave cure (180° prepreg system). Draping and residual stress build up is not included in this topic. The main focus is to define the linkage between the physics in the consolidation step and laminate quality (e.g. porosity) when the tool set is closed and heated to cure temperature.

There is a need to develop a numerical model for the complex three dimensional and integrated composites parts manufactured using an autoclave. Moreover, a central challenge to be addressed is the interaction between the various physical processes; such as the interplay between the autoclave pressure, the tools and the inserts within the part; capability to account for the resin drainage; in-situ consolidation and finally to predict evolution of the laminate quality as a function of the above sub processes.

In summary, the work in this topic is expected to provide a numerical simulation model based on user defined subroutines in ABAQUS, the FE-software used by the Topic Manager. Moreover, it is required that the methodology is documented in form of a manual to support the above design tool. In addition, the necessary experimental procedures required for characterisation of the material properties required by the numerical design tool needs to be defined and documented. Finally a validation of the simulation tool will take place. The Topic Manager has a test tool for a multispar box that can be used for manufacturing tests, the tool allows the variation of several design parameters, see Figure 2.

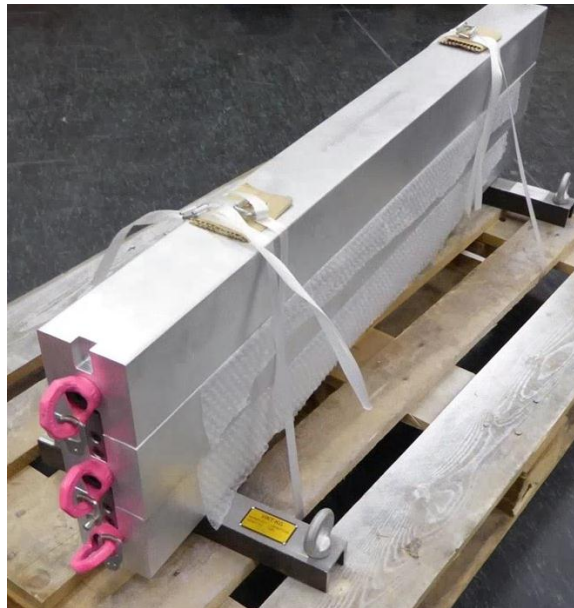


Figure 2. Image of existing multispar test tool to be used to validate the models.

Task 1 - Specification of a process simulation tool for consolidation of highly integrated prepreg parts

A traditional simple part manufactured from a 180° prepreg system usually has a tool set consisting of a one sided tool i.e. a stiff tool on one side and a flexible vacuum bag on the other side of the prepreg. The flexible vacuum bag will ensure a good pressure distribution on the part that will result in good laminate quality. A more complex and integrated composite part often requires a mix of hard and semi-hard tools or caul plates. The level of complexity of the tool will increase in order to obtain parts within the required quality tolerances e.g. porosity and geometry deviations.

The applicant will for a complex mix of hard and semi-hard tools for highly integrated structures:

- Specify all relevant mechanisms to be captured by the process simulation tool and define limitations
- Define the required simulation methodology and the necessary sub models to be implemented as user defined subroutines in ABAQUS to capture the specified mechanisms as defined in Deliverable D1
- Define a validation Test Plan to correlate result from the numerical tool with the existing tool set and the final demonstrator

The process models might include for instance: tool and part geometry, contact conditions (tool-part interaction), pressure, temperature distribution, relevant tooling material behaviour, constitute models that capture the constitutive behaviour of the consolidating composite material. It is expected that the consolidation model will capture the important aspects of the considered process, such as: deformation dependent permeability, the out-of and in-plane constitutive behaviour of the prepreg including the pertinent non-linearities.

Task 2 - Implementation of process simulation model in ABAQUS for consolidation of highly integrated prepreg parts

The task includes development of an FE process model integrated into ABAQUS. The intention of the simulation is to predict the evolution of laminate quality in arbitrary complex 3D parts, with a particular focus on part-tool interaction leading to e.g. prediction of part porosity.

Constitutive consolidation sub model for prepreg

The consolidation model of the prepreg material is crucial for process prediction and has to handle prepreg of different generations e.g. presence of toughening particles and/or Engineering Vacuum Channels (EVaC). The consolidation of EVaC prepreg adds significantly to the complexity of the consolidation process. The trouble is that such complexity cannot be handled by current industrial process simulation software. In the present call, the applicant is asked to develop the modelling tools capable of simulating this complex manufacturing operation.

The applicant will therefore develop and implement a consolidation model for prepreg in ABAQUS to be able to handle an in- and out-of-plane mechanical response at finite strain, the pertinent deformation dependent permeability and micro infiltration process.

Process simulation model in ABAQUS

The applicant will implement the interacting sub models in ABAQUS as defined in Task 1 in order to complete the process simulation tool for consolidation of highly integrated prepreg parts.

Material characterisation

The applicant will define and describe experimental procedures required for characterising material properties for the constitutive sub-models in the process simulation tool. The Topic Manager will define one prepreg material system that the applicant is responsible for defining/identifying the properties for the sub models in the process simulation model in ABAQUS.

Description of methodology

The applicant will develop guidelines and demonstrate the simulation process towards tool-part interaction of complex parts and tooling.

Task 3 - Validation of process simulation tool

The applicant will validate and demonstrate the engineering tool in ABAQUS, the validation will be performed on a tailored manufacture test with relevant features to be defined together with the Topic Manager. In this context, it is expected that the implementation is performed in incremental steps, where increasingly complex models are implemented in ABAQUS and that each increment is verified using physical experiments. The increasingly complex physical experiments are to be agreed with the Topic Manager. It is however expected, that geometries of varying complexity allowing for evaluation of homogenous stress-strain state, as well as mimicking features such as corners and thickness variation, will be assessed. Validation of the developed methodology will be finalized based on manufacturing tests on the test tool shown in Figure 2.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
D1	Specification of process simulation model	Report	T0+7
D2	Constitute consolidation model for prepreg	Report	T0+15
D3	Process simulation model in ABAQUS	Subroutines	T0+18
D4	Material characterisation	Report	T0+21
D5	Description of methodology in a user guide	Report	T0+21
D6	Validation of process simulation tool	Report	T0+36
Milestones (when appropriate)			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
M1	Specification		T0+7
M2	Process simulation model in ABAQUS		T0+21
M3	Validation of process simulation tool		T0+36

4. Special skills, Capabilities, Certification expected from the Applicant(s)

Special skills:

To be able to deliver a complete process simulation tool at the end of the project the applicant must be on a high maturity level and have extensive documented experience from prepreg composite consolidation research including model development, material characterisation and validation. In addition it is important that the applicant can show a track record regarding development of simulation tools for process simulations. The topic must be executed in close collaboration with the Topic Manager. The following skills are requested:

- High maturity level regarding manufacturing research for polymer composites in general and consolidation of preregs in particular.
- Capacity to develop and validate necessary poromechanical models for the process simulation software
- Capacity to characterise the required material properties
- Capacity to plan and execute validation tests/experiments during the project
- Capacity to develop process simulation tools for arbitrary geometries in ABAQUS by implementing relevant models in user defined subroutines.
- Competence in management of research and manufacturing projects.
- Tool design and manufacturing of composite structures with relevant prepreg materials.
- Proven experience in collaborating with aeronautical companies.

Capabilities:

- ABAQUS licence. Version to be agreed on with the Topic Manager although it is expected that the most recent version of ABAQUS available at the time of project start shall be used, currently 6.14.
- In-house equipment and infrastructure for material characterisation
- Experimental manufacturing equipment for continuous validation of sub models implemented in ABAQUS (user defined subroutines) against tailored manufacturing experiments relevant for the demonstrator (multispar test tool in Figure 2) provided by the topic manager.

VI. Complex (composite) part Ultrasonic inspection facilitated by man-robot collaboration

Type of action (RIA or IA)	RIA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	A-3.1		
Indicative Funding Topic Value (in k€)	350 k€		
Duration of the action (in Months)	36 months	Indicative Start Date³⁶	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-AIR-01-13	Complex (composite) part Ultrasonic inspection facilitated by man-robot collaboration
Short description (3 lines)	
The objective of the work is to develop the next generation NDI robot cell for scanning complex integrated composite parts. The cell is preferably equipped with off the shelf robot solutions and state of the art ultrasonic end effectors. Moreover the robot cell shall allow close interaction with an operator without jeopardizing safety aspects.	

³⁶ The start date corresponds to actual start date with all legal documents in place.

1. Background

This topic is part of Airframe High Performance and Energy Efficiency (Activity Line A). The topic is one of the key research activities which will ultimately result in the demonstration of an innovative integrated composite wing structure. This topic is part of Work Package A-3.1: Multidisciplinary wing for high and low speed.

Control surface structures are an essential part of a wing, one control surface which will be an area for research/development in Clean Sky 2 is a highly integrated composite aileron for a large passenger aircraft.

Composite ailerons traditionally have a “black-metal-design” with a low complexity of composite parts manufactured individually and later fastened together in an assembly process. To be able to reduce recurring manufacturing costs new more innovative and integrated composite designs with higher levels of manufacturing complexity have begun to enter the market. Figure 1, left, illustrates an integrated composite structure.

There is a requirement on 100% inspection for aircraft primary structure. Non Destructive Testing (NDT) is a considerable part of the recurring cost. Structures with integrated stiffeners or hollow sections add complexity to the NDT process in several ways, i.e. more difficult to reach all angles and sections. Multi array ultrasonic scanning systems are one technology that is suitable for the inspection of integrated composite components. However, scanning systems that are used in industry are mostly manually operated. Figure 1 shows both an example of an integrated composite component, in this case a multispar aileron structure, and a manual operated NDT equipment used for external ultrasonic inspection.

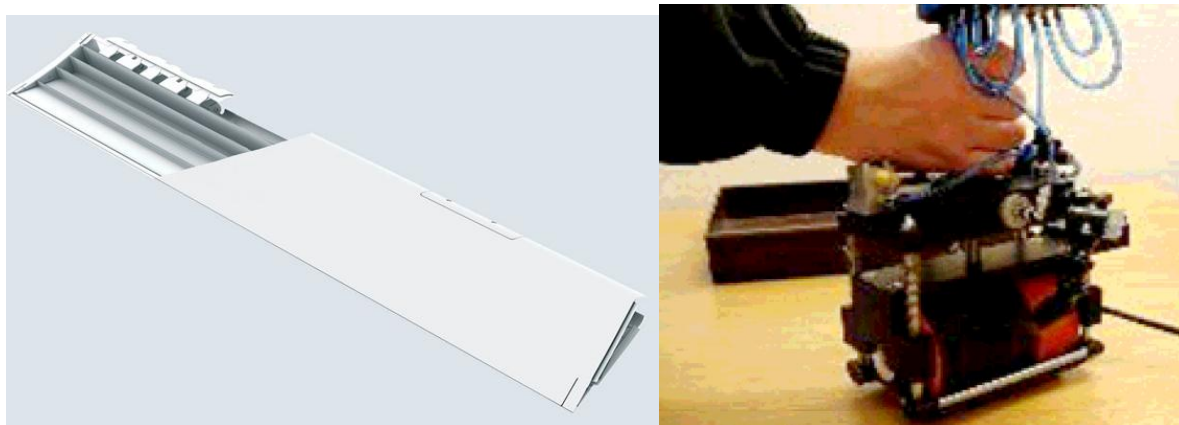


Figure 1. Left: Integrated Aileron composite box. Part of the upper skin is hidden to visualize the internal multispar structure. Right: An early design of an ultrasonic array scan

Ultrasonic NDT operated by robots is an emerging technology area combining different technology systems in order to achieve a more efficient 100% control system in industry. There are robots which are used for NDT in industry today, but these are often large and rigid to be able to provide the sufficient positioning tolerances required for today's NDT technology. Furthermore, these systems

combining NDT with a large robot are well adapted to the inspection of large and “open” configurations such as wing skins or cockpit panels. In the case of a highly integrated component, such as the aileron, geometrical constraints of the “closed box” design puts limitations to the use of the available robotic technology.

Based on the identified industrial needs the focus in this area will be on the combination of scientific and technological knowledge in the areas of Non Destructive Testing (NDT) and Human Robot Collaboration (HRC). The aim is to explore the possibilities to combine these two research areas into specific conceptual solutions that facilitate an inspection cell that has an improved productivity and reduced set-up-time. This shall allow for an increased degree of robotic automation of the NDT process for closed box or similar complex design such as the integrated aileron.

As today's solutions often involve large rigid robots, the end-effector itself is often much lighter than the robot limit payload. There is a desire for a system where a smaller robot can be used for NDT whilst having an end-effector which can conform to part/surface deviations for composite parts.

Focus should be put on strategies that are well adapted to small to middle size complex and “closed box”-like components. Three enabling technologies are foreseen to be further developed and integrated into an inspection process:

- 1) Increased interaction of operator and robot within the NDT cell would allow for a more efficient inspection process. Tools and methods allowing for NDT operator/Inspection robot interaction leading potentially to a collaborative area between an operator and a robot would potentially increase the throughput of the process. This would also potentially allow for other process –such as geometrical control of the part- to take place within the NDT cell.
- 2) Adaptive control schemes of the robotic arm in order to identify the position of the part and quickly ensure the optimal contact or alignment of an ultrasonic probe (or array) with respect to the part to be inspected. This would allow for a more flexible process by reducing the need for absolute positioning of the part. Such an adaptive control could be solved by making use of the ultrasonic probe itself.
- 3) Development of procedures for the remote inspection of parts with low access such as the inspection of integrated spars from the skin side would be greatly beneficial leading to less complex end-effectors. Recently developed techniques, have shown the potential of guided waves for the remote inspection of low access zone, this technique could be considered here.

2. Scope of work

Tasks		
Ref. No.	Title - Description	Due Date
T1	Robot/Operator interaction in a NDT robot cell.	T0+36
T2	Adaptive control of a robotic arm for ultrasonic inspection of a complex component	T0+36
T3	Remote NDT of “low access” part	T0+36

Description of Task 1:

Trends seen currently in the area of robot development include an increased focus on combining emerging sensor technology with more specialised robots in different sizes and payload capability. There are several robot suppliers that have robot arms with 7-axis today and these improve reachability towards more complex geometries and also inside boxes. Furthermore, different sensors and technologies, i.e. force sensors, camera technologiis and laser tracking, are combined with robots in different ways. The next step is to combine the Human and Robot in a Collaborative way sharing the same working volume. Here, the regulations are on reffural and several initatives to evaluate how to work collaboratively are being evaluated in the research phase. They indicate the need to manage the safety issues in the overall production cell. Here, combining NDT with Human-Robot-Collaboration (HRC), it would be beneficial to develop an overall strategy for how to collaborate through the complete task of inspection – which resource is performing each task.

Task 1 shall analyze the inspection flow for a typical integrated composite stucture. It shall suggest a production layout including safety, fixtures, work issues for different resources and how to control the interaction between the operator and the robot carrying NDT equipment. There is a need to identify how and what demands are required to manage a collaborative task focusing on inspection. Furthermore, a risk assessment suitable for inspection tasks in combination with Human Robot Collaboration shall be developed. This task is intended to be conducted in parallel to tasks 2 and 3.

Description of Task 2:

Task 2 will focus on the development of adaptive control schemes for fast and reliable positioning of a robot relative to a complex part for ultrasonic inspection. The system shall be able to maintain the requirements for positioning and orientation of the end-effector (provided by topic manager). This includes the positioning and orientation of an ultrasonic probe specific to ultrasonic inspection in immersion or in direct contact. Several inputs (force controll, ultrasonic signals from the sensor itself) can be considered and shall be discussed with the topic leader. The system shall be able to determine the point of entry of the ultrasonic beam after correction of the beam alignment in order to interact with a scanning program. Here, different innovative ways to control the robot movements over the component shall be evaluated in combination with the needs for collaboration with the operator that is identified in Task 1. This task is intended to be conducted in parallel to tasks 1 and 3.

Description of Task 3:

Task 3 will focus on the development of ultrasonic techniques adapted for the ultrasonic inspection of parts with low access. In particular the research shall address the case of integrated stringers and spars inside “closed box” designs. Potential solutions that would reduce the need for scanning from inside the structure such as the use of ultrasonic guided waves generated from areas of easy access under well controlled conditions are of special interest.

The development work shall focus on the specific requirements associated with the qualification of the NDT process for composite parts in production, providing input and preparing for such a process. This task is intended to be conducted in parallel to tasks 2 and 3.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type	Due Date
D1	Definition of Robot/Operator interaction in a NDT robot cell.	Report	T0+30
D2	Defined methods for adaptive control of a robotic arm for Ultrasonic inspection of complex part	Report	T0+24
D3	Defined ultrasonic inspection technique for low-access areas on composite parts	Report	T0+30
D4	Defined work-flow of a NDT cell for closed box inspection with implemented solutions	Report	T0+36
Milestones (when appropriate)			
Ref. No.	Title - Description	Type	Due Date
M1	Requirements for collaboration schemes between robot and operator in the NDT cell	Report	T0+9
M2	Description of potential collaboration schemes between robot and operator in the NDT cell	Report	T0+15
M3	Definition of principles for adaptive control of a robotic arm for ultrasonic inspection	Report	T0+9
M4	Demonstration of principles for adaptive control of a robotic arm for ultrasonic inspection on simple geometry	Report	T0+18
M5	Description of alternative UT techniques for inspection of low access parts	Report	T0+9
M6	Sensitivity study of alternative UT techniques for inspection of low access parts at coupon level	Report	T0+20

4. Special skills, Capabilities, Certification expected from the Applicant(s)

The applicant should have experience in the development of ultrasonic inspection procedures and robotic applications.

The applicant shall have knowledge and experience of:

- Human/robot interaction and how this correspond with the production system and the cell layout for interacting in an efficient way during the test phase. Furthermore, experience with designing optimized working loops for controlling the robot and identifying optimal control paths is preferred. Experience with adaptive robot control strategies (force or sensor input driven) is also beneficial.
- The applicant shall have preferably access to a number of 7-axis robots of different models, this will be beneficial since it is not obvious which model/type of robot is most suitable for this application. There is a need for the applicant to understand a production system and how to plan for a production task, i.e. inspection, in combination with experience in the HRC research area. Different production tasks using HRC demands different solutions, and earlier experience from both automotive and aerospace in this area is appreciated.
- Development of innovative ultrasonic inspection techniques and procedures including the use of simulation tools:

As it is believed that “classical” UT procedure has limitations for inspection of closed box, the applicant shall have experience of developing innovative solutions in the field of ultrasonic inspection. In particular, documented experience with the use of guided waves, including the use of simulation tools for optimization, is beneficial for solving some of the specific issues with closed box inspection. The applicant shall also understand the aerospace industrial demands on quality assurance and certification issues as well as specificity of composite inspection.

A documented involvement of the applicant in aerospace R&D programs together with the ability to bring new and innovative ideas to laboratory demonstrator is highly valuable.

VII. Technology evaluation of immersive technologies for in-flight applications

Type of action (RIA or IA)	IA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	A-5.1.2		
Indicative Funding Topic Value (in k€)	350 k€		
Duration of the action (in Months)	24 months	Indicative Start Date ³⁷	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-AIR-01-14	Technology evaluation of immersive technologies for in-flight applications
Short description (3 lines)	
The activities shall evaluate the use of immersive technologies (Virtual Reality and Augmented Reality) for passengers and cabin crew during flight operation. Key areas are the impacts on the well-being of passengers and crew as well as evaluating potential technology solutions and applications for ancillary revenue generation and operational efficiency.	

³⁷ The start date corresponds to actual start date with all legal documents in place.

1. **Background**

This work package is aiming to prepare the use of Virtual Reality (VR) and Augmented Reality (AR) for in-flight applications. In anticipation of the quickly evolving markets for consumer products that address these technologies, the activity within ITD Airframe shall provide potential applications that enhance the in-flight experience as well as cabin crew efficiency. The passengers may bring their own devices along soon and expect to benefit from this technology during their travel. In order to address these evolving markets, some scientific foundations have to be established in order to mitigate potential risks and prepare the operational parameters for a safe and economic product portfolio. By maturing the findings on the effects of VR/AR on the passenger well-being and the resulting impacts on the aircraft system architecture, the product landscape can start to grow more quickly and result in sustainable economic market for digital in-flight products.

In the scope of this work, the identification of potential restrictions is a key factor. These restrictions may include:

- Impact on passenger health and well-being (e.g. motion sickness, simulator sickness, injuries, effects on fellow passengers).
- Impact on flight safety and security (e.g. emergency operations, evacuation, data security).
- Impact of legal issues on applications (e.g. restricting (inter-)national laws, copyright licences, patents, cultural etiquette).
- Impact on aircraft system architecture (e.g. airline investments, system redesign, server and network architecture, data bandwidth).

When these risks have been mitigated, the use cases can be adapted in order to increase and demonstrate the benefits for a rapid market introduction. Expected impacted areas are:

- Airline ancillary revenues by providing customized or mission specific content and travel information.
- Enabling door-to-door support with VR/AR applications that address traveller needs.
- Work load reduction or increase of service quality of cabin crew by supporting tasks and information flow within the cabin and to the ground (Airline Operations).
- Evolving application market by utilizing/shaping interface standards and adapting existing business models for developers and market platforms.

2. Scope of work

Tasks		
Ref. No.	Title - Description	Due Date
T1	Identification of technology candidates and evaluation of in-flight applicability	T0+04
T2	Creation of use case for further technology evaluation and human factors analysis	T0+08
T3	Human factors impact analysis	T0+12
T4	Concept proposal	T0+15
T5	Concept demonstrator and evaluation	T0+24

For Task 1, the applicant shall perform a technical analysis of consumer oriented Virtual and Augmented reality solutions on their applicability for in-flight application. This includes the following activities:

- Market overview on available technology solutions for consumer VR/AR (including announced products within a T0+8 timeframe).
- Align criteria for in-flight applicability with topic manager and evaluate the technologies along these requirements.
- Prepare evaluation results for down-selection in cooperation with topic manager. Resulting technology candidates will be used for the following tasks.

Task 2 will require the applicant to define and propose use cases for the technology candidates. The use case will be utilized to assess the human factors impact:

- Define use cases for the down-selected technology solutions. Align with topic manager for selection of use case for the following human factors evaluation referenced in task 3.
- Specify the measurable factors of the human factors impact analysis and define the methodology.

Within Task 3, the applicant shall provide the results of the human factors impact analysis:

- What factors may have a negative or positive effect on passenger health and well-being (e.g. motion sickness, simulator sickness, injuries, effects on fellow passengers).
- Provide scenarios how these factors may be mitigated to an acceptable level.
- Assess the effect of the mitigation actions in cooperation with the topic manager and provide a human factors safety assessment.

The results of Task 4 shall provide one or more concepts for the integration and operation of VR/AR applications during the flight. The concepts shall be based on the results of the previous tasks. The concept shall include:

- Required hard- and software for the user on board.
- Integration description for the on-board systems. Required modifications and interfaces (hard- and software).
- Impact on flight safety and security (e.g. emergency operations, evacuation, data security).
- Impact of legal issues on applications (e.g. restricting (inter-)national laws, copyright licences,

patents, cultural etiquette).

- Impact on aircraft system architecture (e.g. airline investments, system redesign, server and network architecture, data bandwidth).
- Quantitative scenario on the airline business case, based on agreed assumptions with call partners.

Task 5 shall verify and validate the results of the previous tasks by providing a demonstration in relevant environment. This includes:

- Functional demonstration of the use case in relevant environment.
- Remaining risks (if any) for health and well-being impacts.
- Evaluation of test results and final presentation to topic manager.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
D1.1	Market overview	Document	T0+02
D1.2	Criteria for in-flight applicability	Document	T0+02
D1.3	Technology assessment with candidate description	Document	T0+04
D2.1	Use case descriptions	Document	T0+07
D2.2	Human Factors Analysis Methodology	Document	T0+08
D3.1	Human Factors Analysis Document	Document	T0+12
D3.2	Mitigation of Risk Factors	Document	T0+12
D3.3	Human factors safety assessment	Document	T0+12
D4.1	Concept Document	Document	T0+15
D5.1	Demonstrator for use case scenario	Physical demonstrator	T0+21
D5.2	V&V Results	Document	T0+24
D5.3	Final Documentation	Document	T0+24

Milestones (when appropriate)			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
M1.1	Kick-Off		T0
M1.2	Criteria workshop for in-flight applicability	Workshop	T0+02
M2.1	Use case descriptions review	Review	T0+07
M3.1	Human Factors Analysis review	Review	T0+11
M4.1	Concept review	Review	T0+14
M5.1	Demonstrator Review	Review	T0+20
M5.2	Documentation Review and Work Package Closure	Review	T0+24

4. Special skills, Capabilities, Certification expected from the Applicant(s)

The applicant shall:

- Provide extensive technical knowledge on VR and AR technologies and references for at least three previous work results in an industrial environment.
- Have sufficient knowledge on airline operations and aeronautic regulations.
- Provide extensive knowledge on creating VR and AR applications and references for previous work results in an industrial environment.
- Provide extensive knowledge on physiological and psychological impacts of VR/AR technologies on humans.
- Be able to organize, develop, build and perform the means necessary for a verification and validation of the chosen concept.

VIII. Ice protection system based on two-phase heat transport technologies integrated in representative engine intake structure

Type of action (RIA or IA)	IA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	B-2.1		
Indicative Funding Topic Value (in k€)	500 k€		
Duration of the action (in Months)	44 months	Indicative Start Date ³⁸	Q2 2016

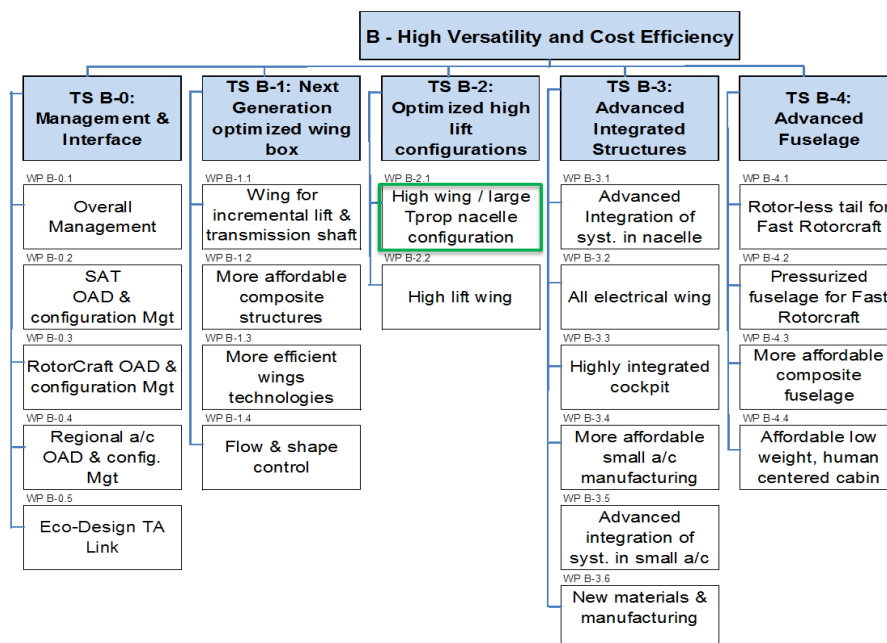
Identification	Title
JTI-CS2-2015-CFP02-AIR-02-08	Ice protection system based on two-phase heat transport technologies integrated in representative engine intake structure
Short description (3 lines)	
The Call for Proposal deals with developing an ice protection system based on two-phase heat transport technologies. The objective is to increase aircraft efficiency by integrating the system within the structure (i.e. representative engine intake structure) and by replacing the traditional ice-protection that require energy from the A/C powerplant with passive devices.	

³⁸ The start date corresponds to actual start date with all legal documents in place.

1. Background

This topic deals with the state of the art in technologies developed for ice protection systems. The function of the ice-protection system is to protect dedicated surfaces (i.e. engine intake) against ice accretion, so that the safety and operation of the aircraft is ensured even during icing conditions (descent or climb through clouds).

The framework of this topic is Airframe ITD *Work Package AIR B-2.1 High Wing Large TurboProp Nacelle Configuration* where specific devices are integrated in nacelle structures in order to wide functionalities without penalizing weight requirements.



The topic is focused in improving engine efficiency and thus reducing fuel consumption thanks to innovative ice-protection systems based on two-phase heat transport system. These devices may be applicable to every surface exposed to ice in the aircraft; in particular engine intakes are good candidates for integration due to proximities to the powerplant.

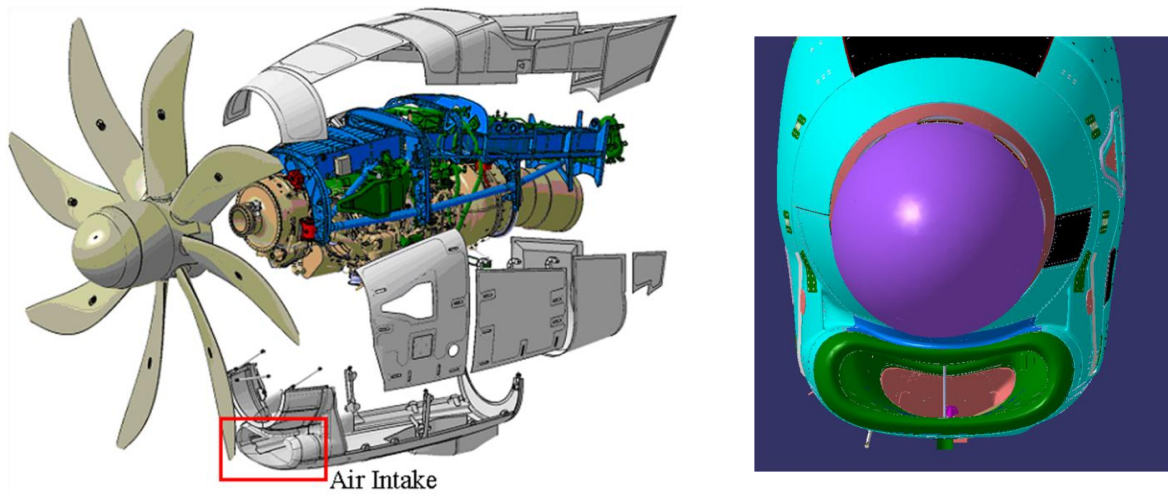


Figure 20. Typical large TurboProp Engine Intake

A typical two-phase heat transport consists of evaporator, condenser and two transport lines (see Figure 21). These are completely **passive devices** that start to operate when sufficient energy is applied at the evaporator. In the same way, they will stop when power is removed.

When the waste energy from the powerplant installation is applied to the evaporator it causes the evaporation of the saturated liquid inside (in a porous wick). The vapour flows through the vapour line to the condenser, which is in contact with the ice accreting surface of the aircraft. As a result of the heat removal, the vapour condenses and the liquid flows through the liquid line to the compensation chamber due to the capillary forces developed in the porous wick.

This innovative A/C concept will be investigated, developed, manufactured and tested in Clean Sky 2 (CS2) program.

The activities under this Call for Proposal (CfP) establishes an important progress beyond the state-of-the-art as no previous systems based on the proposed technology have been implemented and tested before in an aircraft. This project will close the gap between technology validation at laboratory level and prototype demonstration in an operation environment.

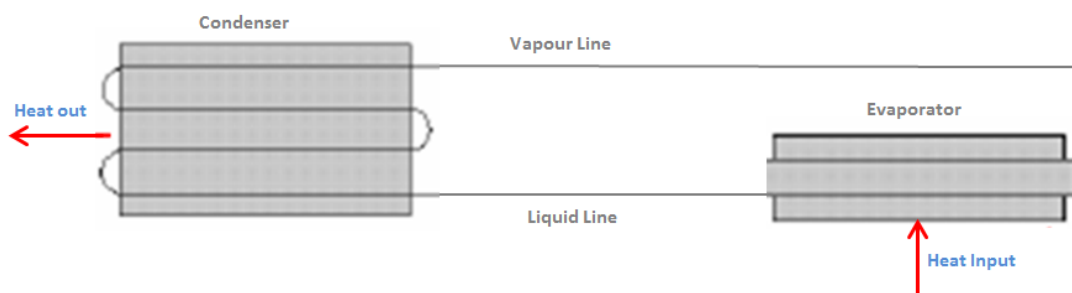


Figure 21. Two-phase heat transport schema

2. Scope of work

Two-phase heat transport technology can be used as a way to recover waste energy from A/C (sub)systems and/or components, using this heat to prevent ice formation in the surface to protect as for example engine air intakes or any other aerodynamic surface susceptible to ice formation.

The objective of this call for proposal is to develop a two-phase heat transport technology application for ice protection, manufacture it and test it. This technology will be developed to have an alternative to the usual ice protection systems (pneumatic and electro-thermal).

The protected surface to be used will be a surface with a specific geometry and whose ice protection will have a minimum heat power input and a minimum surface temperature requirements.

The system to develop will take waste heat from engine installation and this energy will be transferred to the cold surface where the distance between both source and sink will be defined.

The technology challenge is to obtain a system in compliance with the requirements established for an ice protection system of specific surface:

- Develop the concept. Analysis of the system viability to comply with the heat source requirements (high temperatures) and with the sink requirements (surface to protect with a specific geometry i.e. representative of an engine intake).
- Manufacture the developed system.
- Laboratory tests to validate the analysis of viability (Acceptance testing)
- Qualification tests to show compliance with the aircraft high level environmental requirements.
- Two-phase heat transport system prototype testing in ice tunnel bench (a real environment simulator with icing conditions). An ice tunnel is similar to a wind tunnel but able to recreate in a controlled manner the icing conditions the aircraft suffers during flights.

The Topic Manager will be involved in these activities within CS2 to get ice protection system integration in a real aircraft surface which reduces the engine fuel consumption. The global scope of the technological line is a system validated in a representative prototype tested under real environmental conditions.

Tasks		
Ref. No.	Title - Description	Due Date
Task 1.A	System Design of ice protection system of a specific surface Development of <u>system</u> to show the viability. - Analysis of the requirements for the surface to protect: temperatures, powers, geometry, interfaces, weights, etc. - Detailed design of the evaporator with the heat source - Detailed design for the condenser with the cold sink. - Size and detailed design of the <u>completed system</u>. - Mechanical analysis of the detailed design. - <u>Completed system</u> modelled and performance simulation - <u>System prototype</u> design to be tested as validation of the concept. Design the needed tools to manufacture it. - Modelling of the prototype and test results predictions System prototype for vibration tests design	T0+10

Tasks		
Ref. No.	Title - Description	Due Date
Task 1.B	System prototype manufacture - System prototype to validate concept manufacture. - Integration of the prototype with a protected surface prototype. System prototype for vibration test manufacture.	T0+19
Task 1.C	Tests to validate the concept - Test plan - Test of the System prototype - Analysis of the test results Correlation of these results with the thermal model	T0+23
Task 1.D	System test for environmental qualification - Test plan - Support for the vibration tests (vibration tests are not part of the beneficiary scope) Analysis of the test results	T0+25
Task 2.A	Complete System prototype design to test in ice tunnel - Analysis of the requirements of the surface to protect - Detailed design of one prototype system based on two-phase heat transport technologies to integrate it to the representative surface model. Completed System Prototype model to simulate the performances and results predictions.	T0+29
Task 2.B	Manufacture and integration of the <u>complete system prototype with the representative protected surface to test in real environmental conditions (ice tunnel)</u> - Manufacture of the completed system prototype Integration of the system with the representative surface to be protected	T0+41
Task 2.C	Tests of the complete system prototype in ice tunnel. - Test plan - Support to the Topic Manager tests of the integrated system with the surface to protect in ice tunnel. - Analysis of the test results and conclusions Note: Tests in ice tunnel are out of scope of this topic. The applicant will support the Topic manager during the test campaign definition and test results analysis.	T0+44

Requirements and Specifications

The following requirements shall define the design of the system:

- The ice protection system shall protect a representative surface of 0.878 m² total size.
- The heat power density in the ice protected area shall be 20 w/in².
- The maximum temperature in the hot source shall be 250°C.
- The minimum temperature in the surface to protect shall be in the proximities of 40°C.

The Call for Proposal covers design, manufacture and test of a complete system. However, during the specification phase of the project it will be discussed if a representative surface could be used instead of a complete system. Different models, techniques and associated software will be used to simulate the behavior of the ice-protection system based on two-phase heat transport technologies. Activities must be carried out using accurate tools and models to analyze the two phase heat transport. The detailed thermal and mechanical analysis of the coupling between the two-phase heat transport system and the interfaces (Powerplant installation and the surface susceptible of accretion) will be carried out with Finite Element codes (i.e. ANSYS, NASTRAN).

Inputs

The Topic Manager will provide to the beneficiary the following information:

- CAD model files of the A/C surface to protect to define the geometry, provided at T0
- Hot source requirements, provided at T0
- Cold sink requirements, provided at T0
- System requirements, provided at T0
- Surface to protect prototype, provided at T0
- Representative surface to protect prototype, provided at T0+6
- Representative surface to protect for icing tunnel, provided at T0+29

3. Major deliverables/ Milestones and schedule (estimate)

The following deliverables and milestones are defined in accordance with the CS2 scope with the following Topic Manager and beneficiary work-share and nomenclature:

- Dx beneficiary deliverable
- Sx Topic Manager deliverable
- Mx milestones number

Deliverables			
Ref. No.	Title - Description	Type	Due Date
D1	System Design Report	R	T0+10
D2	System Thermal Model	R	T0+10
D3	System prototype to validate concept	D: Hardware	T0+19
D4	System prototype for qualification tests	D: Hardware	T0+19
S1	Surface to protect prototype	D: Hardware	T0+10
D5	Test Plan to validate the concept of the system integrated in the surface specimen	R	T0+19
D6	Test Results to validate the concept analysis	R	T0+23
D7	Comparison of the test results with the thermal model	R	T0+23
D8	System Qualification Test Plan	R	T0+19
D9	System Qualification Test report	R	T0+25
D10	Complete System Integration Report	R	T0+29
S2	Representative surface prototype	D: Hardware	T0+29
D11	Complete system prototype integrated to the representative surface prototype	D: Hardware	T0+41
D12	Test Plan for ice tunnel (real environmental conditions)	R	T0+41
D13	Ice tunnel Test Results analysis	R	T0+44

Milestones (when appropriate)			
Ref. No.	Title - Description	Type	Due Date
M1	Concept Review	RM	T0+5
M2	Preliminary Design Review	RM	T0+10
M3	Critical Design Review	RM	T0+29
M4	Test Readiness Review	RM	T0+41

R: Report - D: Delivery Hardware - RM: Review Meeting

4. Special skills, Capabilities, Certification expected from the Applicant(s)

- Experience in aeronautics
- Experience in heat transfer
- Knowledge and experience in CFD and coupled simulations (i.e. thermo-mechanical)
- Engineering software and licenses for CAD/CAE, CFD, CSM
- Participation in R&T projects cooperating with industrial partners.
- Experience in technological research and development in heat transfer devices.

5. Abbreviations

CAD	Computer Aided Design
CAE	Computer Aided Engineering
CFD	Computational Fluid Dynamics
CfP	Call for Proposal
CSM	Computational Solids Mechanics
ITD	Integrated Technology Demonstrator
JTP	Joint Technical Proposal
R&T	Research and Technology

IX. HVDC Electrical Power Conversion and Distribution System Development

Type of action (RIA or IA)	IA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	B-3.2		
Indicative Funding Topic Value (in k€)	1000 k€		
Duration of the action (in Months)	45 months	Indicative Start Date ³⁹	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-AIR-02-09	HVDC Electrical Power Conversion and Distribution System Development
Short description (3 lines)	
A new electrical power conversion and distribution system more efficient and reliable is needed as the dependence on electric power increases and the necessity to supply systems more critical to the safe operation of the aircraft using HVDC voltages, as, in this case, the Flight Control System actuators.	

³⁹ The start date corresponds to actual start date with all legal documents in place.

1. Background

The aim of this document is to describe all the activities that are involved in the development of a new electrical power conversion and distribution system for essential loads within the frame of Cleansky 2 Airframe ITD.

This innovative A/C concept is based on a set of new technologies that will be investigated and developed in CS2, many of which will be selected for their implementation and integration in the Regional FTB2 Demonstrator according to a higher maturity level and, finally, tested in flight to show a TRL6.

Electrical Power Conversion and Distribution System for High Voltage Direct Current (HVDC EPCDS) has been integrated in Cleansky 1 only for non-essential loads. Therefore, the next step is to develop an efficient and reliable electrical power system supplying essential loads as the Flight Control System, a system with severe safety requirements.

The Figure 22 below depicts the FTB2 Demonstrator, and the set of technologies to be integrated in the Airframe ITD that will require HVDC power supply from the electrical system technologies proposed by the Topic manager to be developed in CS2.

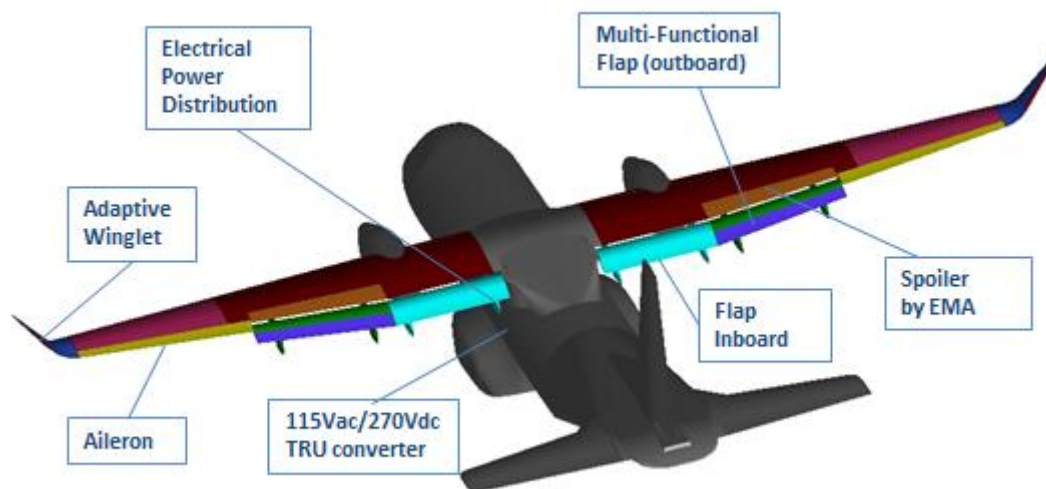


Figure 22. CS2 electrical technologies concept within the framework of the FTB2

2. Scope of work

The activities proposed in this CfP are the design, manufacturing and qualification of the new electrical power system for High Voltage Direct Current (HVDC) for the electrical power supply of essential loads. The main objective of the new electrical power system is to be able to generate in HVDC (270Vdc power supply required for essential loads as EMAs) from the existing voltage levels in the aircraft and to integrate these new demands to electrical power distribution system as well as to integrate new levels of voltage 270Vdc, architectures with new system algorithms including reconfigurations, energy management concepts and power electronic devices.

The technological challenges pursued by the Topic Manager in the framework of the electrical power distribution system technology within CS2 are focused in the HVDC network architecture and in energy management.

In the FTB2 demonstrator, growing capacity, in terms of power supply, is located in the 115VAC variable frequency busbars as it is usually the typical network configurations of similar aircrafts. Recent concepts try to integrate HVDC voltage levels in the aircraft with this kind of voltages. An HVDC voltage level has a lot of benefits and the two main advantages are:

- Weight saving through higher voltage.
- Weight savings through simplified load converters.

But the integration in the aircraft faces still some problems and is still being analyzed to determine the best solution:

- HVDC architectures. There are different kinds of HVDC grids:
 - $\pm 270\text{Vdc}$ two phases with ground
 - $\pm 270\text{Vdc}$ two phases without ground
 - $\pm 270\text{Vdc}$ two phases and isolated
 - 270Vdc one phase with ground
 - $\pm 135\text{Vdc}$ two phases with ground
 - $\pm 135\text{Vdc}$ two phases without ground
 - $\pm 135\text{Vdc}$ two phases and isolated

It is possible to choose the voltage level applied to loads, depending on the characteristics of these loads and also on how the ground is defined in the aircraft. Isolation, for instance, is a critical point that depends on the existing AC system.

- Converter power density. Depending on the converter topology, the weight of the components that could be necessary to include in the architecture shall be taken into account.
- HVDC power converters included in existing networks architectures could introduce a high disturbance and have to comply with strong power quality requirements. Typically, non-regulated output voltages are used in conventional architectures and can produce high variations in the output that could affect more sensitive loads as Flight Control System loads.

Regarding the distribution system, the more electrical aircraft concept requires a more complex load management. Classical load management detects an overload and disconnects loads automatically according to a priority list. A smart energy management concept introduces new algorithms to improve the available capacity in the aircraft. The possible improvements are:

- Variable priorities. Depending on the flight phase, mission, ..., the importance of a load is not constant. The algorithm assigns dynamically the priority of the load depending on several conditions.
- Supervise reconnection. The reconnection of a load is not done immediately after overload is removed but only if a dedicated power level is reached.
- Predictive shedding. The idea of this algorithm is to try to anticipate possible overload when a load is going to be connected.

Moreover, new switching technologies are intended also to be implemented as switching devices based on silicon carbide (SiC) because of their promising applications. Silicon Carbide MOSFETs and power MOSFETs are at their early stages of development and have enormous potential for replacing Silicon based devices. There is great interest in developing SiC MOS devices because of their promising applications in high temperature high power environments. The wide bandgap of SiC makes it ideal for operation in high temperature environments like engines, and oil-wells for power conversion and sensor application. SiC (silicon carbide) power semiconductors can also theoretically reduce on-resistance to two orders of magnitude compared with existing Silicon devices, reducing the total losses in switching devices as much as 10-20% of the normal value obtained with current technology.

All the technologies and systems integrated in the ITD airframe will be tested in flight with the Regional Aircraft FTB2 with enough level of maturity in the Clean Sky 2 program. Therefore, the electrical system will be designed and qualified to obtain the appropriate permit to fly. This process will be also supported with advanced simulation methods to prevent integration problems.

Following Table 5 summarizes the scope of this CfP:

	TECHNOLOGY CHALLENGES	TECHNOLOGY DEMONSTRATORS
HVDC Power Conversion and Distribution System for Flight Control System	▪ 115V AC variable frequency conversion from the voltage provided by the alternate generators to 270V DC of direct current (HVDC) to supply essential loads. ▪ Integration of 270V DC converter into an electrical system based in 115VAC and 28V DC voltages. ▪ Integration of all specific HVDC protection systems (against arc fault, Partial discharge, etc...). Testing of protection systems in flight conditions. ▪ Providing safety critical loads (EMAs that govern the aircraft control surfaces) with 270 Vdc introduces a new challenge in aeronautical applications. Actually HVDC energy has only been considered to provide	▪ Two converter prototypes and one Distribution Box prototype for laboratory test purposes: its main objective will be to mitigate possible risks before reaching a real environment ▪ Two converter prototypes and one Distribution Box prototype for Aircraft to flight test purposes: will validate the electrical design in a real scenario (a second aircraft prototype shipset will be delivered as spare) ▪ Simulation with SABER, Matlab Simulink, AMESim or any other tool required by the Topic Manager to test power quality.

	TECHNOLOGY CHALLENGES	TECHNOLOGY DEMONSTRATORS
	non-essential equipment. Follow with A/C safety standards will lead to reconsider all previous HVDC distribution systems designs and methods. ▪ Following with safety requirements previously mentioned, the aircraft energy management to guarantee a smart energy use has to be reconsidered. Distribution system algorithms including reconfigurations (according with loads safety requirements) and intelligent energy management concepts shall be adjusted. ▪ One important field in this project is to consider new switching technologies. A promising alternative is to build switching devices based on silicon carbide (SiC) because of their promising applications. Silicon Carbide MOSFETs and power MOSFETs are at their early stages of development and have enormous potential for replacing Silicon based devices in high power, high temperature applications. ▪ Intelligent electrical energy management must be tested in flight conditions, with real flight actuators load demand. ▪ Advance modelling and simulation methods to prevent integration problems and support the permit to flight, obtaining processes to anticipate problems in later integration phases.	** All prototypes will be characterized and modelled at functional and behaviour level in a parallel process that could lead to evaluate the deviations of models behaviour against real systems in order to consider the possibility of using models in later certification process. These models will be delivered and clearly described in its enclosed documents and manuals.

Table 5. Technology challenges in electrical power distribution

System Description

The electrical power system for High Voltage Direct Current (HVDC) is comprised of two different equipment:

- TRU converter 270Vdc output voltage regulated.
- HVDC Electrical power distribution box.

The architecture will be comprised by a total of two (2) 15kW 270VDC TRU regulated converters and

the distribution box that will be in charge of the network management and will connect the loads through a line contactor and with the following architecture:

- Each TRU provides a regulated output voltage of 270Vdc/15kW
- A configuration of two separate channels (AC generator + TRU converter + HVDC busbar) corresponding to each side of the aircraft.
- Both channels will work in an independent way, each of one supplying the loads connected to its busbar and will be dimensioned to be able to supply both busbars at the same time in case of reconfigurations due to a failure in the system.

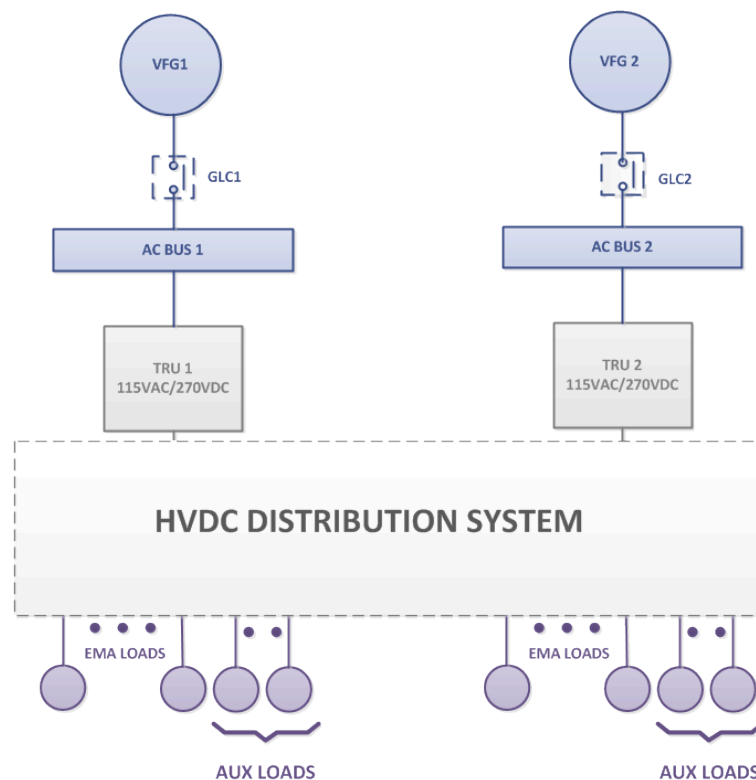


Figure 23. Electrical power conversion and distribution system architecture

In terms of functionality, the main characteristics of the electrical power conversion and distribution system are:

- Providing power at 270Vdc regulated output to essential loads (EMAs that govern the aircraft control surfaces) with the required safety level of criticality.
- Integration of all specific HVDC protection systems (against arc fault, Partial discharge, etc...)
- Integration of 270Vdc system into an electrical system based in other voltages (115Vac, 28Vdc)
- Define new distribution system algorithm including reconfigurations (according with loads safety requirements) and intelligent energy management concepts to manage the energy generated and to comply with load requirements without impacting weight and fuel

consumption.

- Independent control of each load connected to distribution centre. Each load can be commanded by switching on/off the load or by limiting the output current in order to implement different activation and control logics depending on the flight phase, mission, state of the network,...

Protection and control and monitoring

Each equipment (TRU converter and distribution box) will include the protections to assure the good performances of the complete system. At least, protections for over/undervoltage, over/underfrequency, overcurrent/short-circuits will be included and also power quality has to be assured by including protections as voltage ripple, inrush currents, transients, ...

Both equipment will include different interfaces as discrete signals, analogue signals and digital signals to assure the correct communication and operation between both equipment and the rest of the existing electrical system. For instance, measurement points for voltage and currents, failure signals, contactor command, ...

Qualification process

The electrical power distribution system will be flight tested on the Regional Aircraft FTB2 that is a prototype aircraft derived from an aircraft which is civil FAR 25 certified by FAA and EASA Airworthiness regulations; therefore, the electrical power distribution is intended to be also certified to obtain the permit to fly.

To cover that, the equipment will be designed, tested and qualified in accordance with several standards. The main standards used are the following

- MIL-STD-704F. Aircraft electric power characteristics. This standard specifies the characteristics of power inputs and outputs as transients, inrush currents, harmonics, ...
- RTCA DO-160. Environmental conditions and test procedures for airborne equipment. This standard defines a series of minimum environmental test conditions (categories) and applicable test procedures for airborne equipment as temperature, vibration, lightning, voltage spikes, ...
- RTCA DO-254. Design Assurance Guidance for Airborne Electronic Hardware. This standard is used to certify the Hardware included in the equipment.
- RTCA DO-178. Software considerations in Airborne Systems and equipment certification. This standard is used to certify the Software included in the equipment.

FAR25.1309. Safety requirements when installed in the aircraft will comply with the authority regulations.

Modelling and simulations

According to high advances registered in current simulation tools, a parallel process of modelling and simulation, exploring new simulation and testing strategies can help to reduce and mitigate possible project risks and to anticipate deviations of performances in the early stages of the project.

The applicant shall develop detailed models in a specific electrical simulation tool defined by the Topic Manager (mainly SABER), for both WP (TRU converter and electrical distribution box) and follow and adjust them during all the program process to help the FTB2 permit to fly obtaining and

analyze the fidelity of models behavior against real systems.

The models to be delivered are:

- **FUNCTIONAL level.** Functional models are representative of steady-state power consumptions and transients behavior (inrush current, consumption dynamics with regards to input voltage transients...). Such models do not include switching.
- **BEHAVIORAL level.** Behavioral models are detailed functional models. They are representative of actual dynamic waveforms: same representativeness as that of functional models + full representativeness of the waveforms (switching, HF rejections...).

The main activities of the applicant of this CfP will be to define a detailed specification of both equipment (TRU converter and Electrical Distribution Box) by collecting all the high level requirements and the particular requirements by the applicant based on its experience, to perform a full validation and qualification of the equipment to demonstrate the functional behavior and qualification and support the flight test campaign.

Work Packages and Tasks

The proposed activities are grouped in two different Work Packages (WP), one for the power conversion unit (WP1) and another for the Electrical Power Distribution Center (WP2) and each of one has been split in seven tasks. The proposed activities are described in the table below which shows also the deadline for each task, all of them related to electrical system definition and design process.

Each WP has been split in seven different phases/tasks that involves the several stages of design process. These phases are the same for both equipment as they are related to the development of the equipment and are explained in the table:

Tasks		
Ref. No.	Title – Description	Due Date
Task 1	Review phase During this phase, the top level requirements are defined by the Topic Manager taking into account previous analysis performed regarding feasibility of the solution and the impact on the other systems. No activities required from the applicant. The Topic Manager is entirely responsible of this task. Put here only for reference.	<i>T0+6</i>
Task 2	Equipment specification phase In this phase, the applicant will define the specification including the functional requirements and the requirements imposed by the different standards (environmental, installation, safety, maintainability,...). As outcome for this task, the applicant will deliver the SES (equipment specification)	<i>T0+18</i>

Tasks		
Ref. No.	Title – Description	Due Date
Task 3	Design/modification phase The equipment is designed in this phase by the applicant. Several milestones will be held between Topic Manager and applicant to evaluate the progress such as PDR with a preliminary design of the equipment, CDR when the equipment design is frozen and LUAR, with the delivery of the first unit in order to perform the validation phase.	<i>T0+33</i>
Task 4	Modelling phase In this phase, the applicant will deliver the different models levels in order to perform each equipment simulation and validate some specific functionalities. The Topic Manager will integrate these models to perform the complete system simulation.	<i>T0+33</i>
Task 5	Acceptance phase The Topic Manager will perform, once the prototypes have been delivered by applicant, the laboratory test campaign used to perform the integration within the electrical system network. This phase comprises all the test rig definition, test definition and test results analysis. With this outcome, it could be possible that the applicant should modify the equipment to fully comply with specifications.	<i>T0+36</i>
Task 6	Qualification/certification phase In order to obtain the permit to fly by the authorities, the applicant will deliver all the qualification and certification test results. This documentation will be sent by Topic Manager to authorities after its approval.	<i>T0+39</i>
Task 7	Aircraft installation requirements In this phase, the equipment aircraft integration is performed by the Topic Manager. The documentation needed to complete this phase are the wiring diagrams, installation diagrams and harnesses definition. The applicant will support the Topic Manager during this phase.	<i>T0+45</i>

Table 6: Tasks definition and description of activities.

3. Major deliverables/ Milestones and schedule (estimate)

The deliverables and milestones are in accordance with the general work plan of the Regional Aircraft FTB2 demonstrator for electrical power distribution box and correlated to the different tasks as described in the previous section.

Power conversion unit (TRU converter) Milestones

Milestones (when appropriate)			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
M0	Kick-off Meeting (KOM)	<i>Review</i>	<i>T0</i>
M1	Preliminary Design Review (PDR)	<i>Review</i>	<i>T0+6</i>
M2	Critical Design Review (CDR)	<i>Review</i>	<i>T0+18</i>
M3	Laboratory Unit Acceptance Review (LUAR)	<i>Review</i>	<i>T0+33</i>
M4	Permit to Fly	<i>Review</i>	<i>T0+39</i>
M5	Flight	<i>Milestone</i>	<i>T0+45</i>

Table 7. List of Milestones for TRU converter

Milestones (when appropriate)			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
M0	Kick-off Meeting (KOM)	<i>Review</i>	<i>T0</i>
M1	Preliminary Design Review (PDR)	<i>Review</i>	<i>T0+6</i>
M2	Critical Design Review (CDR)	<i>Review</i>	<i>T0+18</i>
M3	Laboratory Unit Acceptance Review (LUAR)	<i>Review</i>	<i>T0+33</i>
M4	Permit to Fly	<i>Review</i>	<i>T0+39</i>
M5	Flight	<i>Milestone</i>	<i>T0+45</i>

Table 8. List of Milestones for Distribution box

At least, the following documentation deliverables will be requested for both WP.

Deliverables			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
D1	Supplier Development Plan (SDP)	Documentation	<i>PDR</i>
D2	Reliability Report (RR)	Documentation	<i>PDR</i>
D3	System Safety Assessment (SSA)	Documentation	<i>PDR</i>
D4	Compliance Matrix	Documentation	<i>PDR</i>
D5	Supplier Equipment Specification (SES)	Documentation	<i>PDR</i>
D6	Interface Control Document (ICD)	Documentation	<i>PDR</i>

D7	Plan for Hardware Aspects of Certification (PHAC)	Documentation	<i>PDR</i>
D8	Plan for Software Aspects of Certification (PSAC)	Documentation	<i>PDR</i>
D9	Failure Modes and Effect Analysis (FMEA)	Documentation	<i>CDR</i>
D10	Failure Modes and Effects Summary (FMES)	Documentation	<i>CDR</i>
D11	Qualification Program Plan (QPP)	Documentation	<i>CDR</i>
D12	Qualification Test Plan (QTP)	Documentation	<i>LUAR</i>
D13	Qualification Test Review (QTR)	Documentation	<i>LUAR</i>

Table 9: List of Deliverables.

4. Special skills, Capabilities, Certification expected from the Applicant(s)

The Applicant shall have the following:

- Experience in electrical systems in aeronautics.
- Involvement with airframe industry
- Knowledge of turboprop A/C type
- Participation in R&T projects cooperating with industrial partners
- Experience in technological research and development in electrical field
- Demonstrated experience (based on history) in design and manufacturing of airborne equipment qualified under RTCA-DO-160, RTCA-DO-178, and RTCA-DO-254 for critical equipment or other civil or military equivalent standards.
- Experience in equipment showing compliance with Electrical Power Normative MIL-STD-704F power quality.
- Capacity to assembly and testing complex aeronautical equipment.
- Experience in integration multidisciplinary teams in concurring engineering within reference aeronautical companies.
- Proven experience in collaborating with reference aeronautical companies, industrial partners, technology centers in:
 - Research and Technology programs (TRL Reviews)
 - Industrial air vehicle with "in-flight" components experience
- Capacity to support documentation and means of compliance to achieve prototype "Permit to Fly" with Airworthiness Authorities (FAA, EASA...)
- Capacity to provide support to system functional tests of large aeronautical equipment: Tests definition and preparation and Analysis of test results. Especially relevant (but not only) for drop test for landing gears.
- Capacity to repair "in-shop" equipment due to manufacturing deviations.
- Quality system international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004)
- Experience with electrical modelling and simulation tools (SABER, Matlab/Simulink, AMESim)

5. Abbreviations

A/C	Aircraft	JTP	Joint Technical Programme
AC	Alternate Current	LTR	Laboratory Test Requirements
		LTRA	Laboratory Test Results Analysis
CDR	Critical Design Review	LUAR	Laboratory Unit Acceptance Revision
CP	Core Partner	OAD	Overall Aircraft Design
CfP	Call for Proposal	PDR	Preliminary Design Review
CS2	Clean Sky 2	PtF	Permit to Fly
CTR	Certification Test Results	PHAC	Plan for Hardware Aspects of Certification
DC	Direct Current	PSAC	Plan for Software Aspects of Certification
		Q/C	Qualification/Certification
EASA	European Aviation of Safety Agency	QPP	Qualification Program Plan
EMA	Electro Mechanical Actuator	QTP	Qualification Test Plan
FAA	Federal Aviation Administration	QTR	Qualification Test Review
FAR	Federal Aviation Regulations	R&T	Research & Technology
FCS	Flight Control System	REG	Regional Platform of Clean Sky 2
FMEA	Failure Modes and Effect Analysis	RR	Reliability Report
FMES	Failure Modes and Effects Summary	SDP	System Platform Demonstrator
FT	Flight Tests	SES	Supplier Equipment Specification
FTB2	Flight Test Bed 2	SSA	System Safety Assessment
GRA	Green Regional Aircraft	STM	Strategic Topic Manager
HVDC	High Voltage Direct Current (270V)	TRL	Technology Readiness Level
IADP	Innovative Aircraft Demonstrator Platform	WBS	Work Breakdown Structure
ICD	Interface Control Document	WP	Work Package
ITD	Integrated Technology Demonstrator		

X. Integrated airborne antenna for satellite communications in wing – fuselage airframe fairing

Type of action (RIA or IA)	IA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	B-3.2		
Indicative Funding Topic Value (in k€)	1100 k€		
Duration of the action (in Months)	50 months	Indicative Start Date⁴⁰	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-AIR-02-10	Integrated airborne antenna for satellite communications in wing – fuselage airframe fairing
Short description (3 lines)	
This topic describes the design, prototyping, manufacturing and testing “on ground” and “in-flight” of an airborne antenna highly integrated into the wing – fuselage airframe fairing. Main deliverables of this topic are the Regional FTB#2 wing – fuselage fairings where the antenna is integrated and operative.	

⁴⁰ The start date corresponds to actual start date with all legal documents in place.

1. Background

The activities under this Call for Proposal (CfP) will support the development of an electronic actuated and sourced innovative Regional Turboprop Aircraft (A/C) concept, FTB2, of the topic manager targeting the Horizon 2020 objectives as described in the JTP document of Clean Sky 2 (CS2).

This innovative A/C concept is based on a set of new technologies that will be investigated and developed in CS2, for their implementation and integration in the Flight Test Bed 2 (FTB2). The framework of this topic is Airframe ITD *Work Package AIR B-3.2 All Electrical Wing* where specific devices are integrated in wing structures in order to wide functionalities without penalizing weight requirements.

The FTB2 demonstrator is based in the topic manager turbo prop transport aircraft with high wing configuration thrustured by two turboprops. So far several efforts have been made in order to enhance the aircraft performances with new wing control surfaces (aileron, flap, spoiler and winglet). This effort in order to achieve a better A/C is aligned with the CS2 objectives of getting more efficient and green transport. Therefore to reduce the excrescences of all the exterior elements is an important purpose.

Nowadays there is a growing demand by airlines, business jets companies and military customers to have high data rate in-flight connectivity for different purposes. This service is possible on board when the aircraft is fitted with a satellite communications (SATCOM) antenna system working at Ka band. The available technology for these antennas is based on mechanically steerable systems using apertures of parabolic dishes (high profile) or partially mechanically/electronically steerable systems using slotted waveguide (medium profile), both covered with bulky radomes. These solutions are protuberant, increasing the aircraft aerodynamic drag, the fuel consumption and degrading its handling qualities.

The latest developments on radiofrequency circuits and microelectronics allow achieving high performance electronic steering antennas and replacing these heavy and bulky antennas. Based on this, the innovation step proposed here is to develop an airborne electronically steerable antenna system for SATCOM at Ka band, highly integrated into the airframe structure, concretely the wing-to-fuselage fairing (WFF) panels of the FTB2 prototype A/C replacing them by new composite structures with embedded antenna elements. This integration concept presents a high innovative and technological component since it must satisfy simultaneously both structural and system functionalities.

Figure 17 depicts the FTB2 Demonstrator and the locations on the WFF panels where the antennas should be embedded.

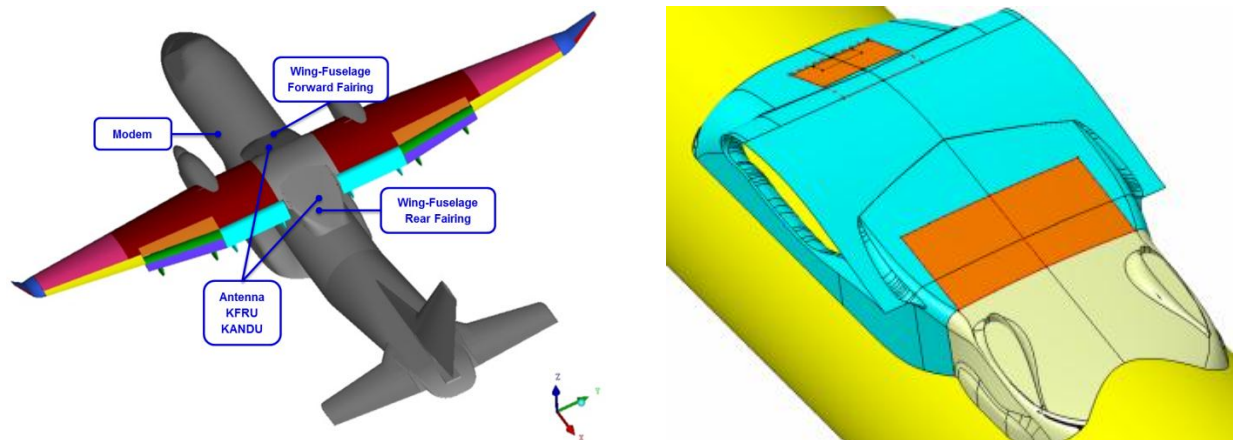


Figure 24: Locations for the embedded electronic steering array antennas within the FTB2 A/C.

2. Scope of work

The main goal of this project is to develop an electronic steering antenna system for SATCOM at Ka band highly integrated into the airframe structure of the FTB2 prototype A/C. The project covers the system design, development, prototyping, manufacturing, qualification, aircraft integration and on ground and in-flight testing to verify its whole functionality.

Based on the above, the involvement of the “Applicant” of this CfP is to design, develop, manufacture and qualify a full SATCOM Ka band antenna system, including the structural components. In addition, the Applicant shall support the topic manager, identified as the Leader within this document, during the on-aircraft antenna integration activities; i.e. its installation, on ground and in-flight test campaign and the clearance for ‘Permit to Fly’ of the FTB2 prototype A/C (to be granted by an European Certification Authority).

The proposed architecture for the whole system is described hereafter;

- Wing – Fuselage fairing panels
- Antenna aperture integrated into the airframe structures, including radiating elements, phase shifters, Ka Radio Frequency Unit (KRFU), Block Up Converter (BUC) and Block Down Converter (BDC).
- Ka Network Data Unit (KANDU)
- Modem Manager (MODMAN)

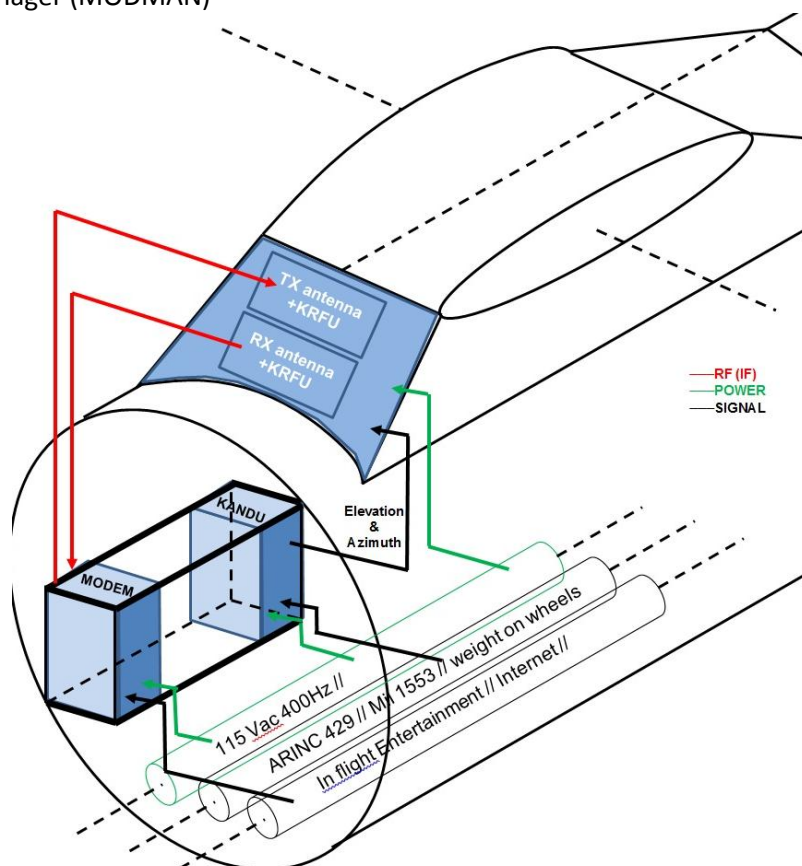


Figure 2: SATCOM system block diagram on ARINC 791

COMPONENT	TECHNOLOGY CHALLENGES	TECHNOLOGY DEMONSTRATORS
Embedded Steering Antenna Aperture	To investigate and select suitable and innovating techniques for integrating electronic components into composite structures satisfying structural and system requirements Achieve the appropriate amplitude and phase feeding distribution fulfilling the radiation pattern regulation and ensuring proper antenna beam forming and tracking To design solid state high power amplifiers (HPA) and low noise amplifiers (LNA) and the heat dissipation mechanisms through the new composite structure	Full electronic steering antenna integrated into new airborne composite structures.
KANDU	To transform, azimuth and elevation control signals into phase and amplitude distribution to properly feed the radiating elements of the array antenna to get the electronic steering.	KANDU Equipment: - Satcom Control Unit - Antenna Control Unit
MODEM	Functionalities of: - Adaptive Code Modulation - Spreading spectrum	-Modem Unit -Controller software

Table 10: Technology challenges in the Electronic Steering Antenna for the REG FTB2 platform

Work Packages and Tasks description

This subchapter describes the work packages in which the project is organized, the details of the tasks and the responsibilities within the entire project.

WP1: Definition of Structure and System Conceptual Design

The objective of this work package is to define the system architecture based on the Applicant experience and to select the appropriate technologies, topologies and the most suitable structural and installation conceptual design for integrating antenna system elements on the aircraft and developing a successful project. A tradeoff between feasible data rate versus regulation (off axis radiation) has to be carried out as well as an assessment of physical size versus regulation compliance. In addition, the following activities shall be also covered within this work package;

- Satellite link budget calculations
- System specification (including the requirements for the new structures)
- Equipment specifications
- System Test Bench and Test Plan definition

This work package shall be under the Applicant accountability; however the Leader shall contribute to the structure and installation conceptual design, as well as the system specification in order to define all the interface requirements between the antenna system and the aircraft.

After this system conceptual design phase, a feasibility design review will take place in order to ensure the viability of the project and carry out the tradeoff solutions.

WP2: Embedded Steering Antenna Aperture and KRFU unit

This work package contemplates all the activities related to the design, development, prototyping, manufacturing and qualification of the antenna aperture integrated into the new composite

structure panels. It has to include the detailed design and breadboard of all the subsystems like radiating element, KRFU, SW, Test Bench... and validation (i.e. electrical values test) building up a small breadboard of the full array. After that the full array manufacturing and associated SW development will be carried out, as well as the full array system validation.

The qualification activity of these elements shall include the radio electrical, EMI/EMC, mechanical, and environmental verification, including vibrations, thermal boundaries and lightning strike effects among others (based on DO160G) in order to demonstrate proper system and structural functionalities. Concretely, the radio electrical verification tests shall be focused on demonstrating proper system performances and fulfilment with the applicable regulation.

As the aim of the project is to demonstrate the viability of the proposed technology in flight, the EMI/EMC, mechanical and environmental verification tests to be performed shall be agreed between the Applicant and the Leader in order to ensure these elements are safe for flight and work properly once installed on the aircraft.

This work package shall be under the Applicant accountability. The Leader shall support to the Applicant for structural design aspects and aircraft interface.

WP3: Ka Data Network Unit (KANDU)

This work package contemplates all the activities related to the design, development, prototyping, manufacturing and qualification of the Ka Data Network Unit (KANDU).

This equipment is in charge of monitoring and control the satellite and aircraft status as well as the environmental conditions. It is the “brain” of the system and therefore it is extremely important to define its architecture and all the input and output interfaces. It receives the aircraft’s attitude and the satellite services database, with this data the steering algorithm must ensure the enough accuracy to aim the antenna beam into the GeoStationary Orbit location and to avoid interferences with other satellites. The control signals of polarization, phase shifters states and amplifiers must be designed to properly feed the radiating elements of the antenna. The control signals must fulfil the operational requirements and the protection against the conducted emissions.

The qualification activities of the KANDU shall include checking its operational functionality and performing the EMI/EMC and environmental verification tests.

Note: operational functionality also includes all the aircraft interface signals.

This work package shall be under the Applicant accountability.

WP4: MODEM unit

This work package contemplates all the activities related to the supplier selection of a COTS (Commercial Off-The-Shelf) Modem unit, its purchase and software modification in order to work properly with the antenna system and perform its intended use; receives the radio-link channel status to change the modulation (Adaptive Code Modulation) and manage the base band contents (WiFi, Ethernet, In Flight Entertainment contents). The adaptive modulation through the tracking channel status must operate correctly and fulfill the environmental requirements.

The qualification activities of the MODEM unit shall include checking its operational functionality and performing EMI/EMC and environmental verification tests (in case of need).

This work package shall be under the Applicant accountability.

WP5: SATCOM Ka band Antenna System Integration Activities at Laboratory level

This work package contemplates all the activities related to the antenna system integration tests at laboratory level to verify the different antenna elements works properly prior to installing them on the aircraft.

The Applicant shall be totally accountable of this work package, including the clearance management with the satellite service provider. The Leader shall support to the Applicant in the definition of the

test bench, specially focused on aircraft interfaces and test strategy.

WP6: SATCOM Ka band Antenna System Integration Activities at A/C level

This work package contemplates all the activities related to the integration of the antenna system on the aircraft, the on ground and in-flight tests campaign.

Most of the activities within this work package shall be performed by the Leader however for some of them it's required the support of the Applicant:

- To define the on-aircraft antenna system installation requirements
- To obtain system clearance for 'Permit to Fly' in front of the European Certification Authority
- To define and perform the Ground Test Requirements (GTR) of the antenna system installed on the aircraft
- To define the Flight Test Requirements (FTR) of the antenna system installed on the aircraft
- To perform the analysis and conclusions of the flight test campaign

Tasks		
Ref. No.	Title – Description	Due Date
Task 1.1	Definition of system architecture	T0 + 3
Task 1.2	Structural and installation conceptual design	T0 + 6
Task 1.3	Selection of the suitable technologies and topologies for antenna design	T0 + 6
Task 1.4	Satellite link budget calculations: By means of analytical calculations, with the appropriate software tools. The satellite link budget must be calculated in order to gather the information about the satellite providers (Geostationary orbit location, Satellite networks, coverages) and expected data rate throughput.	T0 + 3
Task 1.5	System specifications: this document shall provide a description of the system, its architecture, aircraft mechanical and electrical interfaces and all the technical requirements to be fulfilled by the antenna system to perform successfully its intended use in flight once integrated in the FTB2 aircraft.	T0 + 6
Task 1.6	Equipment specifications: after the system specifications, the equipment specs are defined. Antenna + KRFU (in terms of dimensions, RF Front End(s), directivity and efficiency and its integration in the new composite panels), KANDU (tracking, power, polarization signals) and MODMAN (Adaptive modulation, contents manager). The technical specification shall include in detail all the applicable requirements to each of these units.	T0 + 9
Task 1.7	System test bench & Test Plan definition: a specific system test bench and a complete strategy of verification tests, firstly at equipment level, and secondly at system level shall be defined in order to ensure proper structural behavior of the new panels and proper functionality of the antenna system. The definition of these verification tests must allow also demonstrating the fulfilment of the mandatory regulation in order to obtain the clearance for being operated with the selected satellite network provider and	T0 + 12

Tasks		
Ref. No.	Title – Description	Due Date
	being installed on the aircraft.	
Task 2.1	Design of the antenna aperture	T0 + 18
Task 2.2	Design of the new airframe structures	T0 + 18
Task 2.3	Detail integration design of antenna aperture within airframe structure	T0 + 21
Task 2.4	Manufacturing of new panels with embedded antenna aperture	T0 + 24
Task 2.5	Structural qualification tests of new panels	T0 + 26
Task 2.6	Radio electrical, Environmental and Functional qualification tests of antenna aperture	T0 + 30
Task 3.1	KANDU Design	T0 + 21
Task 3.3	KANDU Manufacturing and Testing	T0 + 30
Task 4.1	MODEM supplier selection	T0 + 9
Task 4.2	MODEM SW Modification	T0 + 21
Task 4.3	MODEM Testing	T0 + 30
Task 5.1	Building of Laboratory Test Bench: a specific antenna system test bench shall be built by the Applicant in its facilities.	T0 + 30
Task 5.2	Definition and execution of LTRs: the Applicant shall define and perform the LTR (Laboratory Test Requirements) at both equipment and system level to ensure complete functionality. The verification tests shall take into account also all those activities required to obtain the clearance from the selected satellite network provider. Note: the antenna system test bench shall reproduce all the interface signals with the aircraft.	T0 + 36
Task 5.3	Clearance management with Satellite Service Provider	T0 + 40
Task 6.1	Definition of system installation requirements	T0 + 36
Task 6.2	Definition and execution of GTR	T0 + 43
Task 6.3	Definition and execution of FTR	T0 + 48
Task 6.4	Analysis and conclusions of flight test campaign	T0 + 50

Table 11: Tasks definition and description of activities

Requirements and Specifications

The antenna shall operate at Ka band (20 GHz for reception and 30 GHz for transmission) and shall be able to establish high data rate connectivity (up to 10 Mbps upstream and 50 Mbps downstream).

The whole antenna system must fulfil the radio electrical regulations (ITU-R M1643, ITU-R S2223, ITU-R S580 and ECC 184) and it must be tested with the appropriate facilities under the guidelines of ETSI 303978.

The full SATCOM Ka band antenna system shall be composed of the following elements:

- Antenna aperture set integrated into the new composite material structures: this set or equivalent concept including the radiating elements, amplifiers, mixers, phase shifters and distribution feeding networks will be integrated within WFF panels detailed in Figure 1 and 2. The resulting design shall be conformal to the structure in order to eliminate on-aircraft aerodynamic impact. The new WFF panels shall perform their proper functions as structure, and additionally allocate the aforementioned antenna elements. Special attention shall be paid during the design phase for aspects like stiffness, thermal dissipation and vibrations; critical for proper antenna beam forming.
- One (1) KANDU (Ka band Network Data Unit): this unit receives the attitude data (Ethernet, ARINC429, Mil-STD1553), contains a satellite ephemeris database and calculates the steering direction for the azimuth and elevation. Within this new development the Applicant must design this module to be able to calculate the specific amplitude feeding distribution for the radiating elements of the array and at the same time, it must calculate the phase feeding distribution to properly steer the antenna too. This module is updated with control signals such as attitude data, Tx inhibit, weight on wheels, blanking pulse and satellite link status beacon. Therefore the equipment is requested to behave as antenna control unit and SATCOM control unit.
- One (1) Modem: this equipment receives the radio link channel status to change the modulation and manage the base band contents. The baseline for the MODEM might be a commercial solution; however the Applicant must implement Adaptive Code Modulation (ACM) under the standard Digital Video Broadcasting-Satellite2 (DVB-S2) and spreading spectrum in order to achieve the highest data rate possible under the variable environmental conditions.

The architecture to be proposed shall be in line with the definition given by ARINC 791 "Aviation Ku-Band and Ka-Band satellite communication system".

Main technological challenge is linked to the antenna aperture and its integration into the airframe structure. To minimize risks during the development, this activity shall be performed by the Applicant with the technical support of the topic manager in order to ensure all the structural and system requirements are taken into account in the final design.

KANDU and Modem activities shall be under the responsibility of the Applicant and these should be reduced to modify existing equipment in the market, when feasible.

The Applicant shall be fully responsible of the Laboratory Test Bench and support to the Leader in the on aircraft antenna integration activities and during the flight test campaign.

Effort and costs

An estimation of the effort between the activities is suggested below. Furthermore, details about budget distribution are welcome.

COMPONENT/ACTIVITY	Effort estimated
Embedded Steering Antenna Aperture integrated into airframe structure	70%
KANDU	10%
MODEM	5%
Laboratory Test Bench and Satellite Provider Clearance	10%
Flight Test Campaign and analysis of results	5%

Table 5 Effort required for each main component/activity within the project

Inputs and Outputs

Topic Manager will provide the following information to the Beneficiary:

- Aircraft CAD model files (CATIA, STEP or IGES) related to the specific locations in which the antenna is to be embedded
- The environmental, EMI/EMC, structural, mechanical and thermal requirements applicable to the specific locations of the A/C
- The aircraft-antenna interfaces requirements (electric power distribution and the data buses) to properly feed the equipment of the SATCOM system
- Support in those activities defined in chapter 3

The outputs from the Beneficiary of this call are the following ones:

- Support in those activities defined in chapter 3
- Deliverables defined in chapter 6

3. Major deliverables/ Milestones and schedule

The deliverables and milestones are in accordance with the general work plan of the Regional Aircraft FTB2 demonstrator as shown in Figure 4. The main reference milestones are the Preliminary Design Review (PDR) and the Critical Design Review (CDR) and therefore relevant results and outcomes from this activity have to be provided in advance to these review meetings.

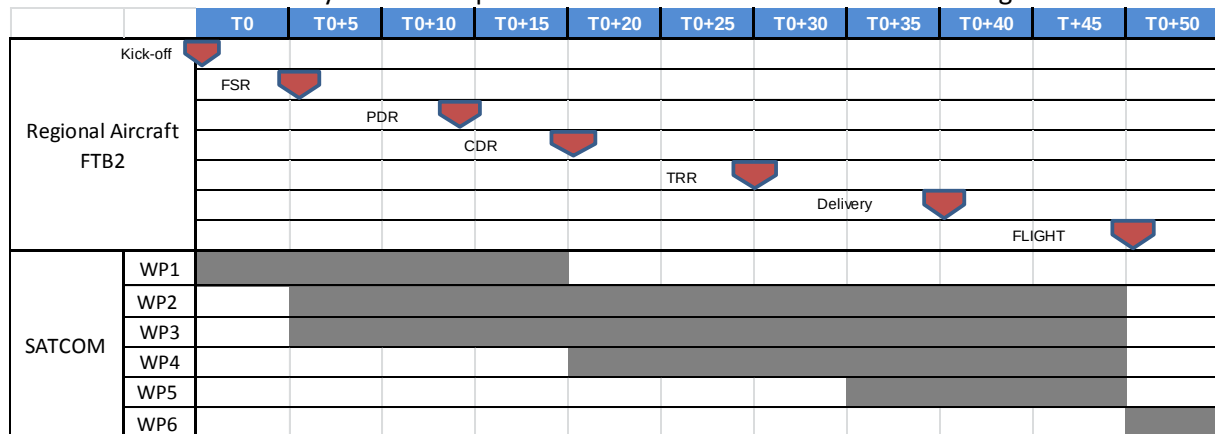


Figure 4: Planning for the Regional Aircraft FTB2 vs. Ka band SATCOM Antenna System

Milestones		
Ref. No.	Title - Description	Due Date
M0	Project Kick-off	T0
M1	Feasibility Design Review	T0+6
M2	Preliminary Design Review	T0+9
M3	Critical Design Review	T0+21
M4	Test Readiness Review	T0+30
M5	Delivery	T0+40
M6	Flight	T0+46

Table 12: List of FTB2 Demonstrator Principal Milestones.

Deliverables				
WP	Ref. No.	Title - Description	Type	Due Date
1	D1.1	Architecture of Antenna SATCOM System integrated into airframe structure	Document	T0 + 3
	D1.2	Satellite link budget calculations and analysis	Document	T0 + 3
	D1.3	Structural and Installation Conceptual Design	Document	T0 + 6
	D1.4	State of the Art Analysis for suitable selection of antenna design technology and topologies	Document	T0 + 6
	D1.5	System Specification	Document	T0 + 6
	D1.6	Equipment Specifications	Document	T0 + 9
	D1.7	System Test Bench Definition and V&V Plan	Document	T0 + 12
2	D2.1	Equipment drawings and electrical schematics	Document	T0 + 21
	D2.2	Equipment CAD model	File	T0 + 21

Deliverables				
WP	Ref. No.	Title - Description	Type	Due Date
	D2.3	Equipment Qualification Test Plan	Document	T0 + 21
	D2.4	Equipment Qualification Test Report	Document	T0 + 30
	D2.5	Structural Qualification Analysis & Test Report	Document	T0 + 30
	D2.6	Equipment DDP	Document	T0 + 30
3	D3.1	Equipment drawings and electrical schematics	Document	T0 + 21
	D3.2	Equipment CAD model	File	T0 + 21
	D3.3	Equipment Qualification Test Plan	Document	T0 + 21
	D3.4	Equipment Qualification Test Report	Document	T0 + 30
	D3.5	Equipment DDP	Document	T0 + 30
4	D4.1	Purchaser Technical Specification	Document	T0 + 9
	D4.2	Equipment drawings and electrical schematics	Document	T0 + 21
	D4.3	Equipment CAD model	File	T0 + 21
	D4.4	Equipment Qualification Test Plan	Document	T0 + 21
	D4.5	Equipment Qualification Test Report	Document	T0 + 30
	D4.6	Equipment DDP	Document	T0 + 30
5	D5.1	Technical Specification for Test Bench Definition and Building	Document	T0 + 24
	D5.2	Laboratory Test Requirements at Equipment level	Document	T0 + 30
	D5.3	Laboratory Test Requirements at System level	Document	T0 + 30
	D5.4	Laboratory Test Results at Equipment level	Document	T0 + 32
	D5.5	Laboratory Test Results at System level	Document	T0 + 35
	D5.6	Satellite Provider Clearance for SATCOM System	Document	T0 + 40
6	D6.1	System ICD and Installation Requirements	Document	T0 + 36
	D6.2	Definition of Ground & Flight Test Requirements	Document	T0 + 40
	D6.3	Equipment delivery for aircraft installation and testing including spares (at least one per equipment)	Document	T0 + 40
	D6.4	Test results of Ground & Flight Test Requirements	Document	T0 + 46
	D6.5	Final report of flight test campaign	Document	T0 + 50

Table 4 List of main deliverables

4. Special skills, Capabilities, Certification expected from the Applicant(s)

- Solid knowledge and capabilities for designing and manufacturing aeronautical structures
- Solid knowledge, capabilities and facilities for designing, manufacturing, measuring, testing (i.e. anechoic chamber in house) and certifying the type of antennas and RF components under the scope of this CfP.
- To have designed, developed and tested an relevant size antenna prototype of a fully electronic steering SATCOM terminal (in X, Ku or Ka band)
- Expertise and products of low profile antennas for Satcom on the Move
- Proven experience in collaborating with reference aeronautical and aerospace companies in R&T programs
- Participation in international R&T projects cooperating with industrial partners, institutions, technology centres, universities and OEMs (Original Equipment Manufacturer)
- Capability of certifying the equipment under ITU, ETSI and FCC regulations and in front of s Satellite Services Providers
- Experience in SATCOM and capability to rent the required bandwidth for the functional test
- Knowledge and experience in analytic calculations for satellite link budget calculations (i.e. MATLAB, STK, or similar)
- Capability of evaluating results in accordance to satellite radio link, expected data rate (upload and download)
- Engineering software and licenses for Computer Aided Design (CAD), Electromagnetic Software, and appropriate high performance computing facilities
- Capability of modifying COTS equipment software and adapting it to the project needs
- Experience in integration of multidisciplinary teams in concurring engineering within reference aeronautical companies
- Capability of specifying, performing and managing, in collaboration with the Leader, structural and functional tests of an aeronautical component and systems
 - Test preparation
 - Systems (hardware and software) and structural elements
 - Instrumentation (sensors, software, analysis)
 - Development
 - Analysis of Results
- Structural and Systems Design and Simulation capacities: structural analysis (i.e. NASTRAN), fluid dynamics (CFD) and design tools (CATIA v5)
- Deep knowledge and experience in the following standards: DO-178C, DO-160G, ARINC 791, ARINC 429, MIL 1553, ARINC 600
- Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004)

5. **Abbreviations:**

A/C	Aircraft
ACM	Adaptive Code Modulation
BDC	Block Down Converter
BUC	Block Up Converter
CAD	Computer Aided Design
CDR	Critical Design Review
CfP	Call for Proposal
CS2	Clean Sky 2
DDP	Declaration of Design and Performances
DVB-S2	Digital Video Broadcasting – Satellite 2
ECC	Electronic Communications Committee
EIRP	Equivalent Isotropically Radiated Power
ETSI	European Telecommunications Standards Institute
FCC	Federal Communications Commission
FDTD	Finite Difference Time Domain
FTR	Flight Test Requirements
GTR	Ground Test Requirements
HPA	High Power Amplifier
IPR	Intellectual Property
ITU	International Telecommunication Union
JTP	Joint Technical Proposal
KANDU	Ka Network Data Unit
KRFU	Ka Radiofrequency Unit
LNA	Low Noise Amplifier
LTR	Laboratory Test Requirements
NDA	Non-Disclosure Agreement
PDR	Preliminary Design Review
R&T	Research and Technology
TRR	Test Readiness Review

XI. Ice protection technology based on electromagnetic induction integrated in representative leading edge structure

Type of action (RIA or IA)	RIA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	B-3.2		
Indicative Funding Topic Value (in k€)	250 k€		
Duration of the action (in Months)	36 months	Indicative Start Date⁴¹	Q2 2016

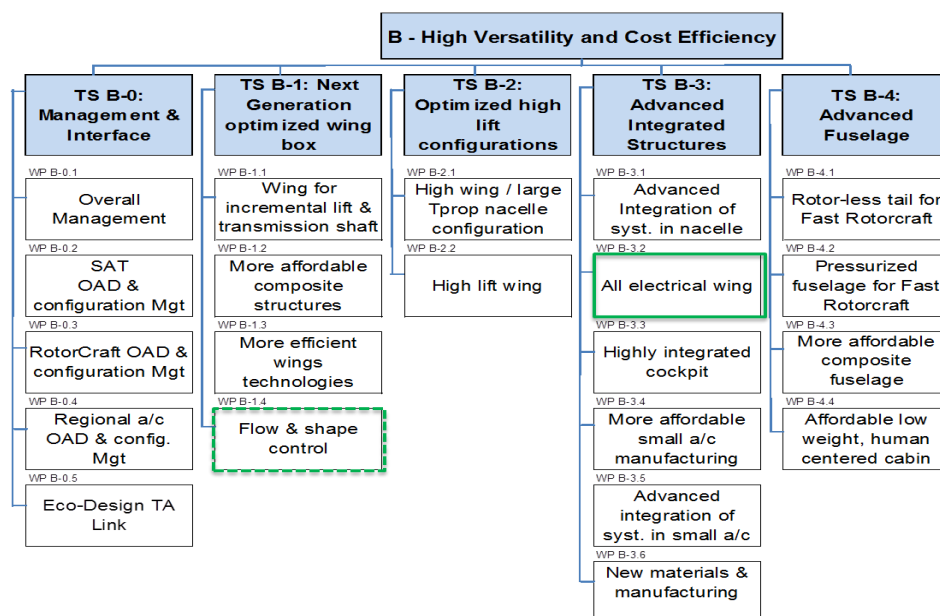
Identification	Title
JTI-CS2-2015-CFP02-AIR-02-11	Ice protection technology based on electromagnetic induction integrated in representative leading edge structure
Short description (3 lines)	
The topic scope is to develop, manufacture and test an ice protection system embedded in a composite structure based on electromagnetic induction technology. Modularity, minimum energy loss, minimum weight and adaptability to concave surfaces representative of wing leading edge are the design drivers of the topic.	

⁴¹ The start date corresponds to actual start date with all legal documents in place.

1. Background

This Call for Proposal (CfP) deals with the state of the art in technologies developed for ice protection systems as well as the integration of these systems within the wing leading edge structure. Wing leading edge structures are prone to ice formation; the proposed ice protection concept in this topic may be potentially applied to this type of surface.

The framework of this topic is Airframe ITD *Work Package AIR B-3.2 All Electrical Wing* where specific devices are integrated in wing structures in order to wide functionalities without penalizing weight requirements. In addition, there are links to *Work Package AIR B-1.4 Flow and Shape Control*.



Ice formation may occur at various aerodynamic surfaces of an aircraft when exposed to icing conditions. Ice accretion on an aerodynamic surface can modify the aerodynamic field around the surface, potentially leading to adverse effects on the aircraft's performance.

A traditional approach to cope with ice includes pneumatic de-icing boots (usually used on propeller-driven aircraft), thermal anti-icing systems (to de-ice wing leading edges & propeller leading edges & engine air intakes), glycol based fluid (usually used to protect wing surfaces & propeller leading edges). All these systems are complex; are high on-board power demanding and require careful maintenance. Design needs to balance reliability and complexity; thus compact, efficient, localized and fast ice-protection system is essential in order to increase the efficiency and reduce the weight of on-board ice-protection systems.

Heating by electromagnetic induction is known as a very fast and efficient method for heating metallic surfaces, with very good controllability of the delivered power as well as for the lack of direct contact between the heated and the heating element. As of now the heating by induction has not been used in aircraft application but seems very suitable and with good potential for heating composite laminate structures.

2. Scope of work

The technology challenge is to obtain a system in compliance with the requirements established for an ice protection system which is highly integrated with the structure of the protected surface (wing leading edge). Therefore concurrent design of the structure and the ice protection is highly required.

The topic is focused on developing ice protection methods for composite laminate structures with a maximum degree of integration between structure and system by using electromagnetic induction. The ice protection concept will be embedded in composite laminates with concave shape and structural requirements of wing leading edges.

- The beneficiary will be responsible of ice-protection demonstration in a reduced scale concave specimen –scope of the actual topic-.
- The Topic manager and other partners in the Airframe ITD will be responsible of technology integration in a full scale wing leading edge for on-ground tests (ice Wind Tunnel Tests, WTT) – which is out of the scope of the present topic-.

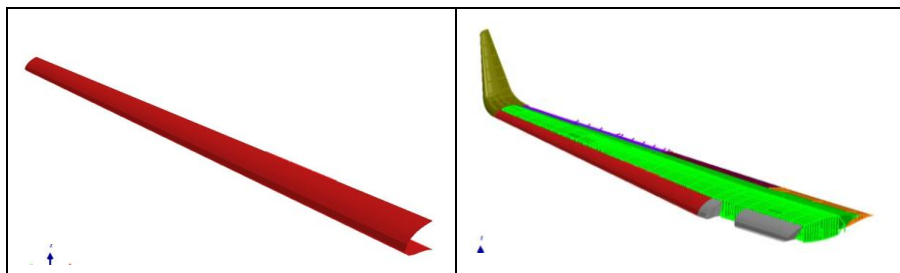


Figure 1. Composite Wing Leading Edge where induction ice-protection will be demonstrated in Clean Sky 2 –out of the scope of the actual topic-

The phases of the project include:

- 1) Definition of the configuration of heated and heating elements in a modular way. Concurrence with structural design of composite laminates. The definition of the structural architecture to be “ice-protected” will be defined by the Topic Manager. The Beneficiary will provide the Design Report in accordance with the the Topic Manager specifications (Task 1), initially in a reduced size specimen for laboratory testing, and later in a representative composite leading edge demonstrator to be developed in Task 2.
- 2) Definition of the power electronics supporting the modularity of the heating elements. The Beneficiary will propose the proper heating elements compatible with the composite structure with enough power to de-ice the component at required conditions (see Requirements and Specifications). Definition of the solution in Task 3 and development of the laboratory demonstrator in Task 4.
- 3) Demonstration in laboratory at Beneficiary facilities of the overall concept. The Beneficiary will develop a reduced size demonstrator in order to test at laboratory facilities the anti-ice capabilities (Task 5) in a representative structure of composite material with typical wing leading edge thickness and plies.
- 4) Pre-integration testing at beneficiary (or designated) facilities of the overall concept. The Beneficiary will integrate the concept, previously demonstrated at reduced size, in a representative leading edge demonstrator provided by the Topic Manager (Task 6).
- 5) Refinement of the system for maximum integration and minimum weight. The Beneficiary will optimize the initial design in order to balance performance of the structure – system interaction in terms of

efficient weight – to – de-icing performance (Task 7).

- 6) Support to the demonstrations of the technology in icing WTT (selected and managed by the Topic Manager) The Topic Manager will test the final leading edge concept in Wind Tunnel facilities with capacities of ice generation (These tests are out of the scope of this topic). The Beneficiary will deliver the demonstrator (Task 8) and support the tests in order to check design criteria versus actual de-icing capacities (Task 9).

The demonstrations at structural level (i.e. impact resistance, static, fatigue, endurance) of the integration of the heating system will not be performed by the beneficiary.

Work Packages and Tasks

Tasks		
Ref. No.	Title – Description	Due date
Task 1	Definition of the heated and heating elements	T0+4
Task 2	Development and laboratory testing of the heated and heating elements in concave structure	T0+8
Task 3	Definition of the power electronics for the heating elements	T0+14
Task 4	Development of the power electronics for the heating elements	T0+20
Task 5	Development and testing of the power electronics with the heated and heating elements in the concave structure	T0+24
Task 6	Pre-integration testing of assembly heated + heating + power electronics (electrical, thermal and EMI/EMC compatibility)	T0+28
Task 7	Refinement of heating elements and power electronics for maximum integration in the concave structure	T0+31
Task 8	Delivery of the heating elements and power electronics integrated in the concave structure for ice tunnel testing	T0+33
Task 9	Support to testing in icing tunnel and results evaluation Note: Tests in ice tunnel are out of scope of this topic. The applicant will support the Topic manager during the test campaign definition and test results analysis.	T0+36

Table 1: Tasks definition and description of activities

Requirements and Specifications

- The ice protection technology based on electromagnetic induction will be tested in a representative composite surface of a wing leading edge exposed to icing conditions.
- The design of the heating elements shall be modular allowing for creation of continuously heated spanwise and chordwise thermal strips. As a first approximation, the space between vertical strips will be 400 mm and the width of the strips 25 mm.

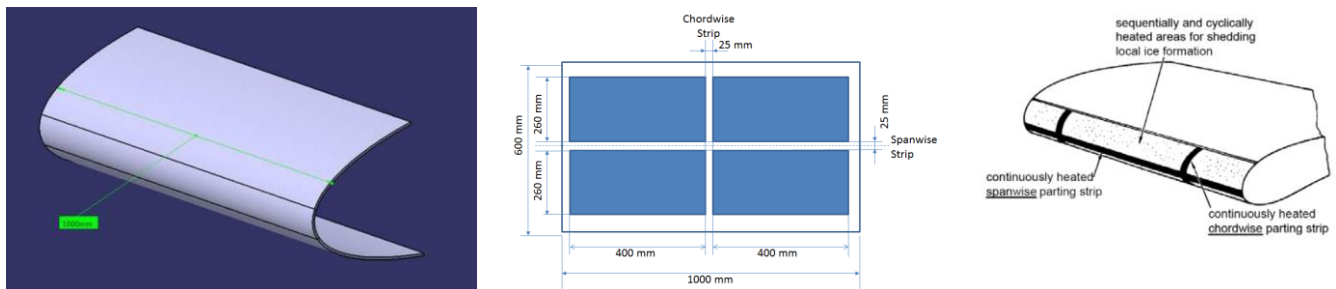


Figure 2. Representative surface of a wing leading edge of composite materials. Conceptual ice-protection system integrated in leading edge structure

- The power density to be provided is in the range of 31kW/m^2 .
- For the demonstration in icing tunnel the heating elements must cover a surface of 1 meter spanwise and 600 mm chordwise (+300 mm in the upper surface and 300 mm in the lower surface). A preliminary validation will be carried out in the beneficiary facilities with at least half of the heating elements.
- As well as for the heating elements, a modular design approach is expected for the power electronics intended for the heating zones.

Inputs and Outputs

The following inputs will be provided to the beneficiary.

- System overall specifications (at T0).
- CAD model files of the leading edge structure to be protected (at T0).
- Composite laminate structure characteristics (material, mesh pattern and thickness) (at T0).
- Structure for laboratory testing (at T0+6).
- Structure for ice tunnel testing (at T0+33).

3. Major deliverables/ Milestones and schedule (estimate)

Ref. No.	Deliverables	Due Date	Milestones
M0	System Requirements Review	T0	SRR
D1	Heated and Heating Elements Design Report	T0+4	
M1	Concept Review	T0+4	CR
D2	Laboratory Tests Plan	T0+5	
D3	Heating Elements for Laboratory Testing	T0+7	
M2	Heating Elements Laboratory Testing Review	T0+7	LAR1
D4	Heating Elements Laboratory Testing Report	T0+8	
D5	Power Electronics Design Report	T0+15	
M3	Preliminary Design Review	T0+16	PDR
D6	Power Electronics for Laboratory Testing	T0+20	
M4	Heating Elements + Power Electronics Laboratory Testing Review	T0+23	LAR2
D7	Heating Elements + Power Electronics Laboratory Testing Report	T0+24	
D8	Pre-integration Tests Plan	T0+25	
M5	Pre-integration Tests Review	T0+27	LAR3
D9	Pre-integration Tests Report	T0+28	
D10	Concepts for Maximum Integration in the Structure	T0+31	
M6	Critical Design Review	T0+31	CDR
D11	Delivery of the Heating Elements and Power Electronics Integrated in the Structure for Ice Tunnel Testing	T0+34	
D12	Ice tunnel Test Readiness Review	T0+34	TRR
D13	Ice tunnel Test Results Analysis	T0+36	
M7	Final Review	T0+36	FR

The Applicant Mission and IPR's

The mission of the beneficiary will be to support in the development of the induction heating technology for ice protection system as set forth in this CfP. The applicant will work in close cooperation with the Topic Manager who will provide the adequate information and models. Further innovations and improvements and



recommendations from specific studies and analysis proposed by the applicant will be welcomed.

All the information and data to be exchanged between the Topic Manager and the Beneficiary of this CfP will be regulated under specific NDA and IPR regulations that will recognize mutually their property following the recommendations and directives of the CSJU.

4. Special skills, Capabilities, Certification expected from the Applicant(s)

- Previous work in Aeronautics.
- Experience in the technologies for ice protection based on electromagnetic induction.
- Capacity to integrate ice-protection technologies in composite laminate structures.
- Experience in design, manufacturing and testing of power electronics, especially dedicated to heating by electromagnetic induction.
- Demonstrated experience in modeling of electromagnetic fields for thin metallic grids / films.
- Participation in R&T projects cooperating with industrial beneficiaries.
- Rapid prototyping capabilities for power electronics and induction winding.
- Experience in research and technology programs.
- Availability of laboratory resources to carry out laboratory tests with the leading edge prototype structure (1mx0.6m) is mandatory.

5. Abbreviations

CAD	Computer Aided Design
CfP	Call for Proposal
ITD	Integrated Technology Demonstrator
JTP	Joint Technical Proposal
R&T	Research and Technology
TRL	Technology Readiness Level
WTT	Wind Tunnel Tests

XII. System development for optical fiber sensing technology measurements for industrial aeronautical contexts: composite manufacturing plants, structural test platforms and airborne conditions

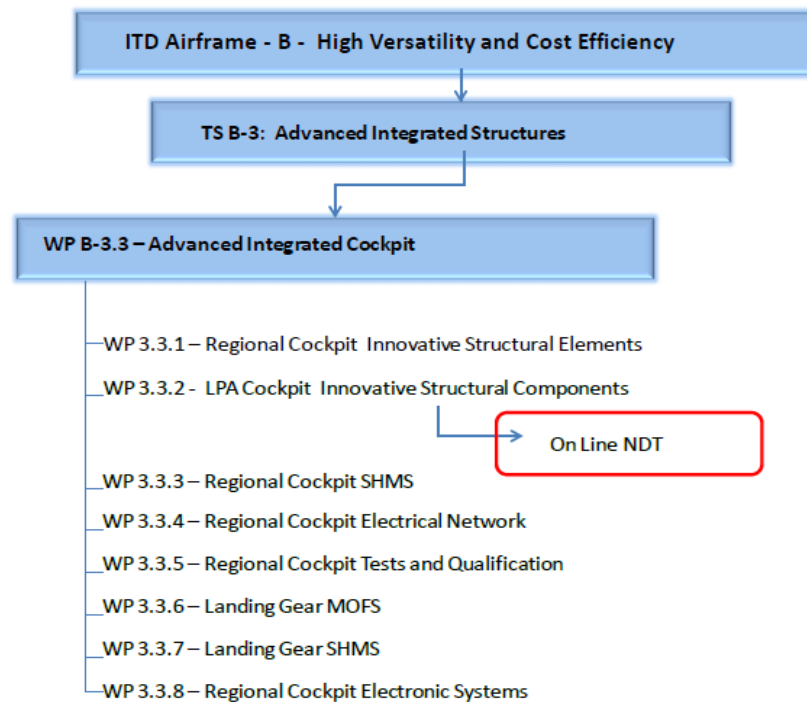
Type of action (RIA or IA)	IA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	A-3.3.2		
Indicative Funding Topic Value (in k€)	350 k€		
Duration of the action (in Months)	30 months	Indicative Start Date ⁴²	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-AIR-02-12	System development for optical fiber sensing technology measurements for industrial aeronautical contexts: composite manufacturing plants, structural test platforms and airborne conditions
Short description (3 lines)	
The project will be focussed on the development of equipment based on distributed optical fibre sensors technology to measure and evaluate the quality and structural health of the composite parts along their different life phases. The system will integrate different acquisition modules and their corresponding interface software adapted to the needs and functionalities of each industrial context.	

⁴² The start date corresponds to actual start date with all legal documents in place.

1. Background

Into the ITD Airframe activity line B, the CfP is linked to WP B-3.3 oriented to highly integrated cockpit and specifically to WP B-3.3.2 “LPA Cockpit innovative structural components –On line NDT” topic as represented by the workbreakdown structure hereunder.



The development will be done in the frame of the “On-line NDT” project, to facilitate implementation of “Online NDI/Process Monitoring” in composite manufacturing processes.

The objective of work package is to develop, qualify and apply innovative test and measurement technologies for efficient, high quality testing of integrated demonstrators.

The technological field is optical fibre sensing, already well known for damage detection or unacceptable shape deformation detection.

In comparison with classical monitoring technologies, optical fiber sensing technologies have demonstrated industrial interest and high level of sensibility, impacting by reducing installation time and providing further other functionalities such as data transport, temperature and pressure measurements.

The project will be focussed on the development of equipment integrating all elements in one. It will be based on distributed optical fibre sensors technology that will measure and evaluate the quality and structural health of the composite parts along their different life phases. The system will integrate different acquisition modules and their corresponding interface software adapted to the needs and functionalities of the industrial context.

The context of the development is typically starting at the manufacturing stage of the parts. The system would contribute to the quality control of the parts by optical fiber introduced in this initial phase. Then when the parts are loaded either in structural test platforms or in-service life, the same optical fibers will output information about their integrity in comparison with a distributed threshold previously defines.

The developed system must then be adapted to each context of use from one end until the latest one.

2. Scope of work

The partner contribution to WP 3.3.2 - will be to develop a system specific to damage detection in composite structures by optical fibres sensor technology, on medium and large scale structures, where system data acquisition and analyser needs to be adapted to the different scenarios such as control quality in production, and structural health in structural test conditions.

Essential aspects such as, specification, installation and integration of the system, operational mode and validation plan will be defined with the topic manager.

Specifically, the partner shall develop a multifunctional prototype with capability to monitor large areas such as complete fuselage, wings, vertical or horizontal tail plane of passenger commercial aircrafts. It will be compatible with conditions existing in each scenario. It will provide a spatial resolution measurement of at least 5 mm and the possibility to take back data from optical fibres covering 150 m length. The weight of the system would aim to a maximum of 4.75 kg. The sensing fiber should not require any previous grating increasing the cost of the technology and limiting the number of the sensing points.

The developed system will be integrated into one typical industrial application that will be selected with the topic manager. At the end of the project, the deliverable prototype will be validated based on the research context.

After the project the prototype will be implemented by the Topic manager (TM) on one of the LPA platform 2 demonstrator that will be selected also by the topic manager in order to be tested and validated in accordance to applicable standards to complete the full validation process of the system.

Tasks		
Ref. No.		Due Date
1	Identification and definition of the requirements specific to the industrial contexts with the topic manager inputs (applicant and topic manager).	M04
2	Design and development of the first version of the prototype (applicant)	M12
3	Evaluation of prototype in manufacturing scenario that will be delivered by the topic manager (applicant and topic manager)	M15
4	Integration and evaluation of the prototype on a demonstrator that will be delivered by the topic manager in laboratory environment (applicant and topic manager)	M18
5	Integration and evaluation of the prototype on a full scale demonstrator that will be delivered by the topic manager (applicant and topic manager)	M20
6	Finalization of the prototype based on feedbacks from previous evaluations (applicant)	M24
7	Verification & Validation loop of the new prototype version on full scale demonstrator that will be deliverable by the topic Manager (applicant)	M30

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
1	Compilation of the requirements	Report	M5
2	Supply of β -equipment version	prototype	M12
3	Evaluation of prototype in manufacturing scenario	Report - Milestone/decision gate	M15
4	Description of system capabilities when Integrated on a demonstrator in lab context identifying needed improvement	Report	M19
5	Description of system capabilities when integrated on a real industrial demonstrator	Report	M22
6	New prototype version	Prototype	M24
7	Verification and validation of the delivered prototype	Report - Milestone/decision gate	M30



4. Special skills, Capabilities, Certification expected from the Applicant(s)

Skill 1 – Deep knowledge in Optical fiber sensing elements

Skill 2 - Experienced in typical optical fiber data analysis processes in aeronautical context.

Skill 3 – Typical reflectometry signal analysis related to optical fiber sensors.

Skill 4 – Ability to adapt the prototype to a multipurpose scenario integrating manufacturing -mechanical test bench unit and typical aircraft system's constraints.

Capability 1- Lab platform offering all electronic engineering capabilities needed to develop new equipment and realize characterizations.

XIII. Prototype Manufacturing Tooling for Single Parts Manufacturing of the Rotorless tail for LifeRCraft

Type of action (RIA or IA)	IA		
Programme Area	ITD AIRFRAME		
Joint Technical Programme (JTP) Ref.	B.4.1		
Indicative Funding Topic Value (in k€)	750 k€		
Duration of the action (in Months)	34 months	Indicative Start Date ⁴³	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-AIR-02-13	Prototype Manufacturing Tooling for Single Parts Manufacturing of the Rotorless tail for LifeRCraft.
Short description (3 lines)	
The aim of this Call for Partner is to develop, design, manufacture and deliver to the CoP of the CfCP AIR-02-02, the prototype manufacturing toolings for all single parts of the LifeRCraft Rotorless Tail that belong to the WP_B4.1 “Rotorless Tail for LifeRCraft”. The development of this tooling should be innovative in order to implement the best performances in the following fields: • Low Cost Materials • Eco-design • Energy savings • Manufacturing processes simplification-Production time savings. Always ensuring that each one of the single parts manufactured with the prototype tooling fit with the Aeronautical quality standards.	

⁴³ The start date corresponds to actual start date with all legal documents in place.



1. **Background**

The Fast Rotorcraft Project (FRC) aims at demonstrating that the compound rotorcraft configuration implementing and combining cutting-edge technologies, as from the current Clean Sky Programme, opens up to new mobility roles that neither conventional helicopters nor fixed wing aircraft can currently cover in a sustainable way, for both the operators and the industry.

The project will ultimately substantiate the possibility to combine in an advanced rotorcraft the high cruise speed, low fuel consumption and gas emission, low community noise impact, and productivity for operators. A large scale flightworthy demonstrator embodying the new European compound rotorcraft architecture will be designed, integrated and flight tested.

In addition to the complex vehicle configurations, Integrated Technology Demonstrators (ITDs) will accommodate the main relevant technology streams for all air vehicle applications. They allow the maturing of verified and validated technologies from their basic levels to the integration of entire functional systems. They have the ability to cover quite a wide range of technology readiness levels.

The present call belongs to the scope of the ITD Airframe and is closely linked to IADP FRC.

The LifeRCraft Rotorless Tail will have the following major components IAW (In Accordance With) the current design status:

- Tail Boom
- HS Horizontal Stabilizer.
- VS Vertical Stabilizer.
- Control Surfaces
- Others (e.g. access doors or panels)

The components ready-for-flight will be integrated in the air vehicles with the objective of bringing Technologies to Full Scale Flight Demonstrators levels (Full TRL 6).

Therefore this Call for Partner belongs to the WP_B4.1 "Rotorless Tail for LifeRCraft" of the Airframe ITD and to the Technology stream identified as activity line High Versatility and Cost Efficiency (HVCE).

The partner selected through this call shall manufacture all prototype toolings required to produce all single parts belonging to that before mentioned components of the rotorless tail.

The Prototype tooling set needs to comply with the different raw materials (Composite and/or Metallic, others...) and manufacturing procedures (OoA, Autoclave, others...) selected by the Leader and Core Partner, which are responsible for the development of the rotorless tail in accordance with the Technical Specification for the Rotorless tail.

The Core Partner (CoP) for the AIR-02-02 will have been selected by the time of the start of the work described in this CfP and this CoP will be the responsible for manufacturing of all the single parts of the WP_B4.1 devoted to the Tail Unit for FastRCraft. So the CoP will lead and manage all the activities described in this document, always under the supervision of the Leader.

Therefore the Partner that will be selected for this Call will be the responsible to develop, design, manufacture and deliver to the CoP the tooling set for all single parts needed to manufacture the Rotorless tail IAW the materials, manufacturing processes and technical specifications selected or developed by the Leader and the CoP.

2. Scope of work

INTRODUCTION

The objective of most of the technologies involved in the Airframe ITD is to reach a maturity level necessary to allow flight testing of the rotorless tail on the LifeRCraft demonstrator, in the specific case.

The LifeRCraft is a prototype air vehicle based on the architecture described in the Patent FR07-03615 with high-mounted wings which accommodate the transmission shafts driving two tip propellers. It features an airplane-like tail. No tail rotor is needed as the differential propeller pitch ensures main rotor torque balance and aircraft yaw control in hover and low speed.

The prototype tooling set for single parts subject to this Call for Partner belongs to the tail unit of the LifeRCraft air vehicle, with around 5.5 m reference length . The main components are shown in Figure 1.



Figure 1. Structural components of the LifeRCraft tail unit***

The architecture of the tail is preliminary and may change during the Pre-design phase. The Rotorless tail design will be frozen at the PDR.

The Tail Unit comprises the following main structural elements and all structural sub-elements belonging to it:

- Tail Boom
 - Tail Boom structure/ Mechanical interfaces to Centre/Intermediate Fuselage
 - Capability of being dismountable.

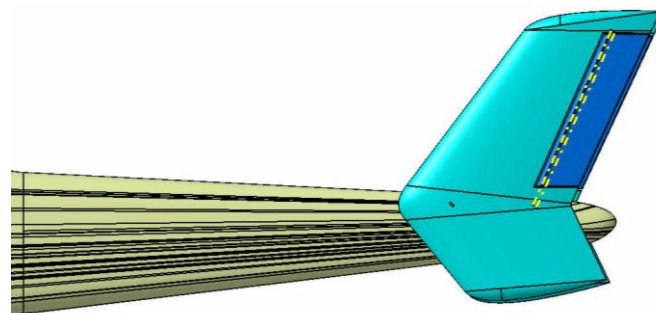


Figure 2. Tail Boom and Vertical Stabilizer with its control surfaces (***)

- HS (Horizontal Stabilizer with Control Surfaces)

- HS Structure/ Mechanical interfaces to Tail Boom, VS and actuators.
- Capability of being dismountable.

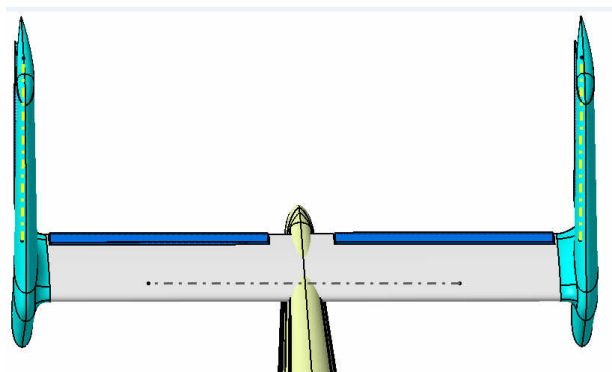


Figure 3. Tail Boom/Horizontal Stabilizer/Vertical Stabilizer with its control surfaces (***)

- VS (Vertical Stabilizer with Control Surfaces)
 - VS Structure/ Mechanical interfaces to HS and actuators.
- Control Surfaces
 - Control Surfaces Structures/ Mechanical interfaces to HS and VS.
- Fairings and Doors
 - Tail Boom Fairing (TBC)
 - Access doors

(***) All the Major parts described, the single parts represented in the figures and the geometries, sizes and shapes of all of them are not frozen and are in accordance with the current design status, as it was mentioned in this document. Other possible configurations could be assessed during the CfP application time and therefore these figures and information are just for a preliminary reference. The final configuration will be frozen at the PDR.

COMPONENT	POSSIBLE TECHNOLOGY CHALLENGES (i)	DIMENSIONS(**)	NUMBER of ELEMENTS
TAIL BOOM	Possible innovative manufacturing processes: •Pre-preg •Full Barrel laminating •Co-curing Reduction of production time, single parts and part fixations	Reference dimensions: • Length:4500-5500mm • Diameter in root 1000mm See Figure 2.	▪ 1 specimen kit for Ground Tests ▪ 1 specimen kit ready for flight
HS	Possible innovative materials and manufacturing processes: •RTM •Pre-Preg •Fitting Integration (TBC)	Reference dimensions: • Span 4000-5000mm	▪ 1 specimen kit ready for flight

COMPONENT	POSSIBLE TECHNOLOGY CHALLENGES (i)	DIMENSIONS(**)	NUMBER of ELEMENTS
	Reduction of production time, single parts and part fixations	Width 1000 mm See Figure3.	
VS	Possible innovative manufacturing processes: •RTM •Pre-Preg •Fitting Integration (TBC) Reduction of production time, single parts and part fixations	Reference dimensions: • High:2500 mm • Width 1000 mm See Figure 2.	▪ 1 specimen kits ready for flight. ▪ Each kit has two VS. ▪ VS Design has to be compatible with possible introduction of dimensional reductions IAW inputs received from Flight Test Campaign.
CONTROL SURFACES	Possible innovative manufacturing processes: : •RTM •Pre-Preg •Fitting Integration (TBC) Reduction of production time, single parts and part fixations	Reference dimensions: • HS-Control Surfaces:1700 x200 mm • VS-Control Surfaces:1000 x200 mm	▪ 1 or 2 specimen kits-TBC IAW the final Tail Configuration shape: ○ H Shape-Needs two kits one for HS and another for VS. ○ VS Shape-Needs only one kit. ▪ Each kit has two Control Surfaces. ▪ The CSs of the VS have to be compatible with possible introduction of dimensional reductions in the VS, IAW inputs received from Flight Test Campaign.
Upper T/B Fairing (TBC)	Possible innovative materials and manufacturing processes: • Out-of-Autoclave • High module thermoplastics Reduction of production time, single parts and part fixations Resistance to high in-service temperatures	Reference dimensions: TBC/TBD-in terms of a developed surface approx a Square surface of 1200mmx1200mm	▪ 1 specimen kit ready for flight-(If Need/If Apply). ▪ This topic is pending to Tail Shape selection (TBC)

(i) Possible Manufacturing processes that currently are under evaluation for applying them into the single parts of these major parts.

(ii) (**)The dimensions included in this Table are approximately. These values will be frozen during Preliminary Design.

Table 1. Tail Unit structural components manufactured by the Core Partner

The Core Partner will manage the Partner in agreement with the Leader. The CoP will closely work with the Leader from the conceptual design of the components, design requirements, material selection, manufacturing processes and final specimen deliveries for structural and functional tests “on-ground” and “in-flight”.

In general, the conceptual design of every component will be driven by the leader while the detailed design; manufacturing and partial assembly (applicable) will be done by the CoP. A high level of concurrent engineering is required all along the project to coordinate design phases, manufacturing, system integration and assembly in “on – ground” and “in – flight” demonstrators.

The final requirements and features needed for the Prototype Manufacturing tooling will be provided by CoP IAW the Leader at the beginning of the project with the delivery to the Partner of the Technical Specification for the Tooling.

The Partner will be supported by the CoP during the Prototype Tooling Design and Manufacturing phases. The Leader will support them if necessary.

The CoP will support the Partner with the following tasks:

- Design Trade-off Studies/Conceptual Studies.
- Material and Production Trade-off Studies for Production process selection.
- Perform Preliminary Design, Sizing and Documentation for each single parts tooling under manufacturing responsibility of the CoP and/or Sub-Assemblies and/or Assemblies (If applicable) just after PDR.
- Test Plan Drafting.
- Manufacturing trials campaign.

The Partner shall:

- Propose the most suitable and innovative tooling design for the chosen technology to be applied for each Single Part, including mould, drill, trim, etc... to produce a part according to the drawing set.
- Define and Manufacturing Prototype Tooling that will assure the full functionality of each Single Part and, if needed, modify their designs in order to improve Single Part functionality.
- Define and Manufacturing Prototype Tooling that will assure the demanded quality of each part IAW the Technical Specifications.
- Generate a tooling documentation IAW the core partner specification. This documentation will include, at least, geometrical definition and geometrical control (if needed) of the tooling in line with the requirements laid down by the CoP. Work with geometrical verification means e.g. laser tracker.
- Delivery of the Prototype Tooling set for Manufacturing to the CoP facilities in appropriate transportation means.
- Support Set up in the CoP premises.
- Modify the PT manufacturing tooling IAW possible design modifications after the CDR. Impact limits of this kind of modification (if needed) will be negotiated.
- Follow up of the works performed by Leader and the CoP until the end of the assembly of the flightworthy demonstrator.
- It will be appreciated and desirable if defined Prototype Tooling could simplify the single part

manufacturing process when compared with current tooling systems.

- The implementation, in the Prototype Tooling Design, of innovative and low cost concepts in terms of Materials and Design processes will be appreciated.
- Identify and report at least the following information: RC, weight (if applicable), materials, manufacturing procedures, LCA data, etc....always establishing the study versus the current solutions applied in industry.

The following paragraph describes in more detail the need of the Leader and its CoP (who will lead and manage the partner of this CfP and all the activities performed by it) about the prototype tooling for manufacturing, aim of this document, in liaison with the possible technologies to be applied in the design of the Rotorless Tail parts for LifeRCraft.

- In the case of hand lay-up and pre-preg technologies application, the prototype tooling developed by the partner shall be as far as possible innovative and low cost, in order to achieve the manufacturing processes in just one shot of highly integrated CFRP parts of the Tail Unit, in order to save energy and manufacturing times needed for manufacturing. Also the implementation of new or innovative materials for prototype moulding manufacturing will be considered interesting by the CoP and Leader, but always taking into account the Leader request about the TRL level. See chapter 4.
- In the case of the application of RTM/LRI technologies; the partner activities should be focus on obtaining a prototype tooling that shall have the following features:
 - A self-regulating system with embedded, advanced sensors to monitor the process at all times.
 - Reduce overall energy consumption by optimize the cycle, in particular reducing the resin cure time.
 - Lead to an overall reduction in energy costs of about 15%.
 - Surface Quality IAW the standards of the Aeronautic Industry.

The prototype tooling development shall include also all the additional toolings needed for manufacturing processes IAW the single parts designs (preforms tooling, injection tooling, curing tooling, drilling templates, etc.) and external heating systems, if needed, (like electric system, blankets, water system, oil systems). The electronic control is necessary and needs to be IAW the technologies selected by the single parts design-See table 1.

By other hand and in order to provide a clear view of the tasks and works to be done by Partner, the WBS for the HVE B4.1 Tail Unit for the LifeRCraft Demonstrator is enclosed.

The WBS shown in figure 2 provides a clear view of the work to be done by Partner in the frame of HVE_B4.1 project for LifeRCraft demonstrator.

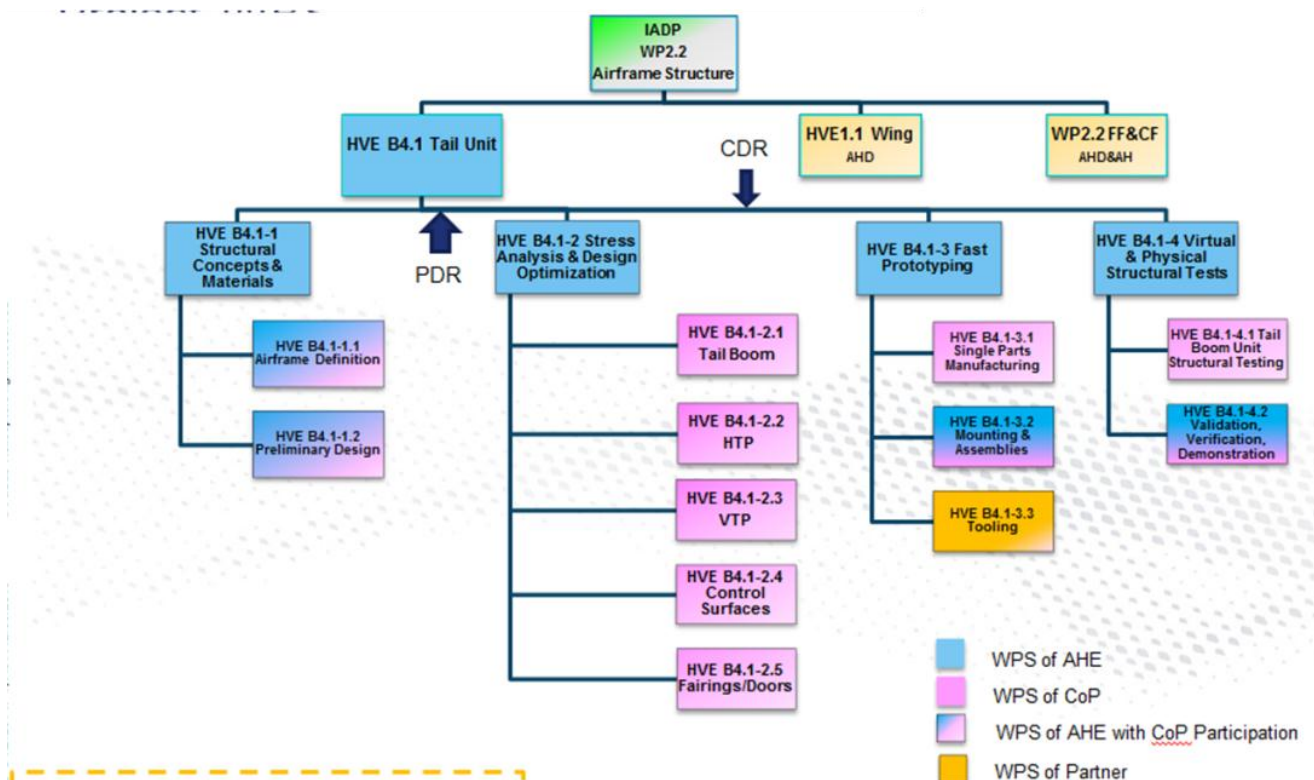
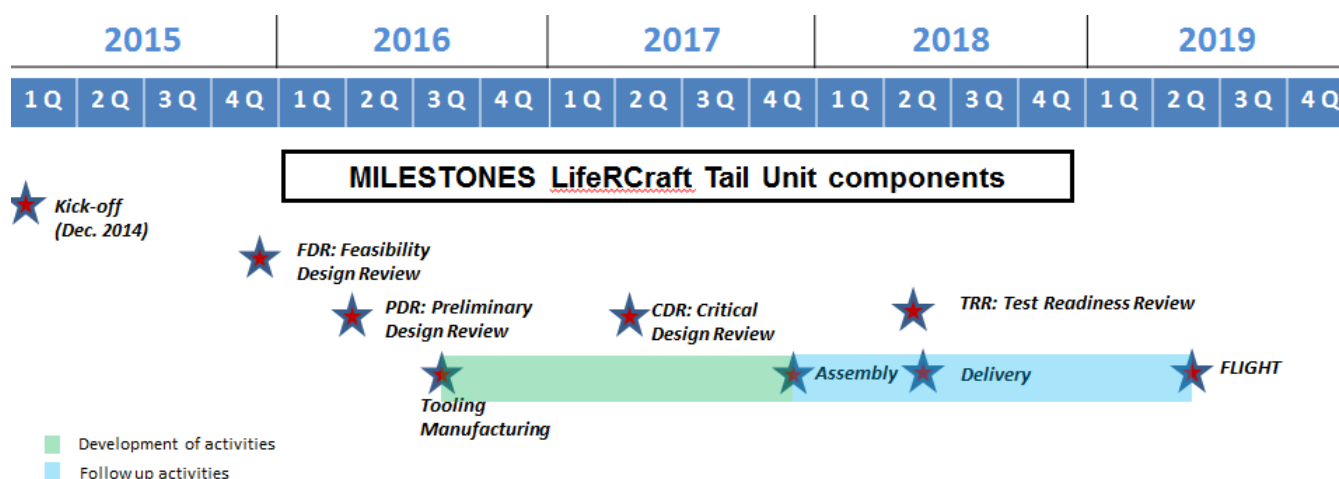


Figure 2. WBS for HVE_B4.1 Rotorless Tail for FastRCraft.

The Leader and the CoP will provide the information (design documentation, general requirements specification...) to the Partner IAW their roles and responsibilities to enable the Partner to perform all relevant tasks related to this CfP. In addition, permanent support of the partner by the CoP is envisaged. The following harmonization tasks have to be done before the start of the work:

- Method and Tool harmonization (substantiation, IT, Program management)
- Quality assurance process harmonization
- Communication management
- Content of substantiation file-if needed for prototype tooling.

3. Major deliverables/ Milestones and schedule (estimate)



Deliverables expected from Partner			
Ref. No.	Title – Description	Type	Due Date*
1	Inno. Prototype Mnf. Tooling: - Prototype Tooling ready to produce parts (including heating system-if necessary) - Auxiliary tooling, complementary to the injection and curing, needed for preparing the preforms. - Quality inspection reports-CoC - Tooling Manufacturing Report - Prototype Tooling Maintenance and Working Orders. - Manufacturing Orders	Toolings Report Drawings Hardware	$T_0 + 08$ until $T_0 + 10$
2	Inno. Prototype Mnf Tooling Assessments: - Assessment Reports for each Prototype Tooling about: ○ Trade off Report ▪ Materials, RC, Weight, LCA.... ○ Thermal Simulation Report - Final Report with Conclusions and Lessons Learned.	Report	$T_0 + 12$ until $T_0 + 16$
3	Follow up Activities: - Design documents, 3D models, Tooling manufacturing reports etc... (Idem than Deliverable n°1&2) for possible Tooling modifications during follow up phase.	Toolings Report Drawings Hardware	$T_0 + 16$ until $T_0 + 34$

* T_0 Is the starting date of the activities to be performed by the applicant.

Inputs to be delivered by CoP and/or Leader to Partner			
Ref. No.	Title – Description	Type	Due Date*
1	<i>Task for Leader and/or CoP-Technical documentation from Rotorless Tail PDR:</i> - CATIA Models and drawings from PDR. - Tooling Technical Specification(TBC)	Report Drawings	T_0
2	<i>Manufacturing Processes:</i> - Proposed materials (CoP) and manufacturing processes	Report	T_0
3	<i>Task for Leader and/or CoP-Technical documentation from Rotorless Tail CDR:</i> - CATIA Models, drawings and reports from CDR.	Report Drawings	$T_0 + 05$ until $T_0 + 08$

* T_0 Is the starting date of the activities to be performed by the applicant.

4. Special skills, Capabilities, Certification expected from the Applicant(s)

(M) – Mandatory; (A) – Appreciated

- Experience in design and manufacturing of manufacturing tooling for structures in non-conventional and conventional composite materials (thermoset and thermoplastic –regular and high temperature conditions-) and innovative metallic components (M)
- Design and analysis tools of the aeronautical industry (i.e. CATIA v5 r21 (M), NASTRAN (M), VPM (M), Windchill (A).
- Experience in management, coordination and development technological (Aeronautical) programs. (M)
- Proved experience in collaborating with reference aeronautical companies with industrial air vehicle developments with “in – flight” components experience. (M)
- Participation in international R&T projects cooperating with industrial partners, institutions, technology centres, universities and OEMs (Original Equipment Manufacturer). (A)
- Competence in management of complex projects of research and manufacturing technologies. (A)
- Experience in the following fields (A):
 - Innovative processes in composite materials (i.e. thermoset, ISC thermoplastic, thermo-forming, In-Situ Co-consolidation with no-welding, Out of Autoclave technologies).
 - High Temperature Materials for Structural Applications.
- Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004). (M)
- Regulated facilities for the use of laser in manufacturing process. (A)
- Capacity of providing tooling for large aeronautical components manufacturing within industrial quality standards. (M)
- Capacity to repair or modify “in-shop” the prototype manufacturing tooling for components due to manufacturing deviations. (A)
- Qualification as strategic supplier of manufacturing tooling on aeronautical elements. (A)
- Experience and know-how with tooling for OoA Technologies: RTM, Infusion, SQRTM, In-Situ Co-consolidation, Thermoforming, Roll-forming. (M)
- Experience and know-how with tooling for manufacturing metallic components. (M)
- Advanced Non Destructive Inspection (NDI) and tooling inspection like (A):
 - Dimensional and shaping inspections
 - Morphology studies of materials-if needed.
 - Ultrasonic inspection capabilities.
- Contactless dimensional inspection systems. (A)
- Simulation and Analysis of Tolerances and PKC/AKC/MKC (Product, and Manufacturing Key Characteristics). (A)
- Into the eco design field, the Partner shall have the capability to monitor and decrease the use of hazardous substances regarding REACH regulation (M).

It is expected, that only technologies which are at TRL4 will be proposed for the prototype innovative manufacturing tooling. The above mentioned requirements will be fixed in more details during the partner agreement phase, after selection. This will also include the IP-process.

5. Abbreviations

TRL	Technology Readiness Level		M&A	Mounting and Assembly
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OoA	Out of Autoclave	QG	Quality Gate
RTM	Resin Transfer Molding	R/C	Rotor Craft
SQRTM	Same Qualified RLEADER	RRs	Roles and Responsibilities
LRI	Liquid Resin Infusion	TBC	To Be Confirmed
IR	Infra Red	TBD	To Be Defined
XCT	X-ray Computerized Tomography	VS	Vertical Stabilizer
POA	Production Organization Approval	WBS	Work Breakdown Structure
DOA	Design Organization Approval	WP	Work Package
EASA	European Aviation of Safety Agency	COS	Conditions of Supply
FAA	Federal Aviation Administration	SPC	Super Plastic Forming
LCA	Life Cycle Analysis	ALM	Additive Layer Manufacturing
LCCA	Life Cycle Cost Analysis	AHE	Airbus Helicopters Spain
OEM	Original Equipment Manufacturer	CfP	Call for Partner
R&T	Research and Technology	CI	Configuration Items
NDI	Non Destructive Inspection	HS	Horizontal Stabilizer
IP	Intellectual Property	HVE	High Versatility and Cost Efficiency
CoP	Core Partner	IAW	In Accordance With
ISC	In-Situ Co-consolidation	ITD	Integrated Technology Demonstrator
TU	Tail Unit	JTP	Joint Technical Proposal
SMR	Structural Manufacturing Responsible	SDR	Structural Design Responsible
		CS	Control Surfaces

XIV. Prototype Tooling for Sub-Assembly, Final Assembly and Transport of the Rotorless tail for the Compound RC.

Type of action (RIA or IA)	IA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	B.4.1		
Indicative Funding Topic Value (in k€)	350 k€		
Duration of the action (in Months)	32 months	Indicative Start Date ⁴⁴	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-AIR-02-14	Prototype Tooling for Sub-Assembly, Final Assembly and Transport of the Rotorless tail for the Compound RC.
Short description (3 lines)	

⁴⁴ The start date corresponds to actual start date with all legal documents in place.

The aim of this Call for Partner is to develop, design, manufacture and deliver to the Leader and/or the CoP of the CfCP AIR-02-02, all the prototype Assembly, Sub-Assembly and Transportation tooling needed to pre-assemble, assemble and transport the Compound RC Rotorless Tail.

The development of this tooling should be innovative in order to implement the best performances in the following fields:

- Low Cost/ Natural Materials
- Eco-design
- Energy savings
- Assembly processes simplification-Assembly time savings.
- Simplify Transportation processes.



1. Background

The Fast Rotorcraft Project (FRC) aims at demonstrating that the compound rotorcraft configuration implementing and combining cutting-edge technologies, as from the current Clean Sky Programme, opens up to new mobility roles that neither conventional helicopters nor fixed wing aircraft can currently cover in a sustainable way, for both the operators and the industry.

The project will ultimately substantiate the possibility to combine in an advanced rotorcraft the high cruise speed, low fuel consumption and gas emission, low community noise impact, and productivity for operators. A large scale flightworthy demonstrator embodying the new European compound rotorcraft architecture will be designed, integrated and flight tested.

In addition to the complex vehicle configurations, Integrated Technology Demonstrators (ITDs) will accommodate the main relevant technology streams for all air vehicle applications. They allow the maturing of verified and validated technologies from their basic levels to the integration of entire functional systems. They have the ability to cover quite a wide range of technology readiness levels.

The present call belongs to the scope of the ITD airframe and is closely linked and managed by IADP FRC.

The LifeRCraft Rotorless Tail will have the following major components IAW (In Accordance With) the current design status:

- Tail Boom
- HS Horizontal Stabilizer.
- VS Vertical Stabilizer.
- Control Surfaces
- Others

The components ready-for-flight will be integrated in the air vehicles with the objective of bringing Technologies to Full Scale Flight Demonstrators levels (TRL 6).

Therefore this Call for Partner belongs to the WP_B4.1 “Rotorless Tail for LifeRCraft” of the Airframe ITD and to the Technology stream identified as Activity Line High Versatility and Cost Efficiency (HVCE).

The scope of this call is to obtain sub-assembly, assembly and transportation tooling to integrate all single parts of the rotorless tail of the compound RC in sub-assemblies and assemblies and transport them also. The sub-assembly will be performed by the CoP in the case of HS, VS and others if necessary such as Control Surfaces, fairings and doors. In the case of the Tail Boom it will be performed by the Leader. Therefore the associated toolings need to be delivered to the CoP and the Leader in accordance with the already described workload distribution. The final assembly of the tail unit is planned to be done by the Leader, i.e. the relevant toolings need to be delivered to the Leader.

The selected partner shall develop, design, manufacture and deliver to the CoP and/or the Leader all the prototype tooling in accordance with the technical requirements of the Rotorless Tail Parts and compatible with the standards for a serial aeronautical production/assembly and transportation.



The Prototype tooling set for sub-assembly and final assembly has to be compliant with the raw materials (Composite and/or Metallic, others...) and manufacturing procedures (OoA, Autoclave, others...) selected by the CoP and the Leader. Idem for transportation prototype tooling set.

The Core Partner (CoP) for the AIR-02-02 will be responsible for the manufacturing of all single parts needed to build the rotorless tail unit of the Compound RC.

Therefore the Partner selected for this Call will be the responsible to develop, design, manufacture and deliver all prototype tooling for the sub-assembly of the Rotorless tail parts and the final assembly, including all the “secondary toolings” as drilling templates, locating templates etc...and the “management tooling”, like work platform, slings, turning device, etc..., always IAW the materials, manufacturing processes and technical specifications selected or developed by the CoP and the Leader. The same conditions applies for transportation tooling.

2. Scope of work

INTRODUCTION

The objective of most of the technologies involved in the Airframe ITD is to reach a maturity level necessary to allow flight testing of the rotorless tail on the LifeRCraft demonstrator, in the specific case.

The LifeRCraft is a prototype air vehicle based on the architecture described in the Patent FR07-03615 with high-mounted wings which accommodate the transmission shafts driving two tip propellers. It features an airplane-like tail. No tail rotor is needed as the differential propeller pitch ensures main rotor torque balance and aircraft yaw control in hover and low speed.

The prototype tooling set for subassembly, assembly and transportation subject to this Call for Partner belongs to the tail unit of the LifeRCraft air vehicle, with around 5.5 m reference length. The main components are shown in Figure 1.



Figure 1. Structural components of the LifeRCraft tail unit^{***}

The architecture of the tail is preliminary and may change during the Pre-design phase. The Rotorless tail design will be frozen at the PDR.

The Tail Unit comprises the following main structural elements and all structural sub-elements belonging to it:

- Tail Boom
 - Tail Boom structure/ Mechanical interfaces to Centre/Intermediate Fuselage
 - Capability of being dismountable.

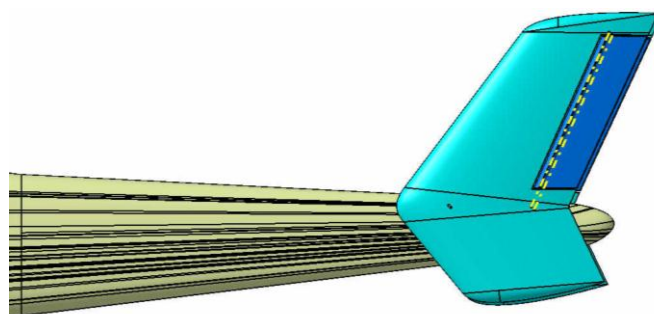


Figure 2. Tail Boom and Vertical Stabilizer with its control surfaces^(***)

- HS (Horizontal Stabilizer with Control Surfaces)
 - HS Structure/ Mechanical interfaces to Tail Boom, VS and actuators.
 - Capability of being dismountable.

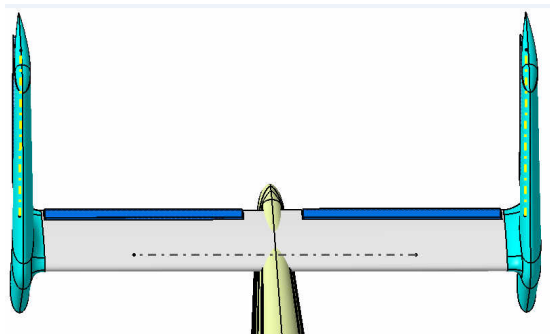


Figure 3. Tail Boom/Horizontal Stabilizer/Vertical Stabilizer with its control surfaces(***)

- VS (Vertical Stabilizer with Control Surfaces)
 - VS Structure/ Mechanical interfaces to HS and actuators.
- Control Surfaces
 - Control Surfaces Structures/ Mechanical interfaces to HS and VS.
- Fairings and Doors
 - Tail Boom Fairing (TBC)
 - Access doors

(***) All the Major parts described, the single parts represented in the figures and the geometries, sizes and shapes of all of them are not frozen and are in accordance with the current design status, as it was mentioned in this document. Other possible configurations could be assessed during the CfP application time and therefore these figures and information are just for a preliminary reference. The final configuration will be frozen in the PDR.

COMPONENT	POSSIBLE TECHNOLOGY CHALLENGES (i)	DIMENSIONS(**)	NUMBER of ELEMENTS
TAIL BOOM	Possible innovative manufacturing processes: •Pre-preg •Full Barrel laminating •Co-curing Reduction of production time, single parts and part fixations	Reference dimensions: • Length:4500-5500mm • Diameter in root: 1000mm See Figure 2.	▪ 1 specimen kit for Ground Tests ▪ 1 specimen kit ready for flight

COMPONENT	POSSIBLE TECHNOLOGY CHALLENGES (i)	DIMENSIONS(**)	NUMBER of ELEMENTS
HS	Possible innovative materials and manufacturing processes: •RTM •Pre-Preg •Fitting Integration (TBC) Reduction of production time, single parts and part fixations	Reference dimensions: • Span 4000-5000mm • Width 1000 mm See Figure3.	▪ 1 specimen kit ready for flight
VS	Possible innovative manufacturing processes: •RTM •Pre-Preg •Fitting Integration (TBC) Reduction of production time, single parts and part fixations	Reference dimensions: • High:2500 mm • Width 1000 mm See Figure 2.	▪ 1 specimen kits ready for flight. ▪ Each kit has two VS. ▪ VS Design has to be compatible with possible introduction of dimensional reductions IAW inputs received from Flight Test Campaign.
CONTROL SURFACES	Possible innovative manufacturing processes : •RTM •Pre-Preg •Fitting Integration (TBC) Reduction of production time, single parts and part fixations	Reference dimensions: • HS-Control Surfaces:1700 x200 mm • VS-Control Surfaces:1000 x200 mm	▪ 1 or 2 specimen kits-TBC IAW the final Tail Configuration shape: ○ H Shape-Needs two kits one for HS and another for VS. ○ VS Shape-Needs only one kit. ▪ Each kit has two Control Surfaces. ▪ The CSs of the VS have to be compatible with possible introduction of dimensional reductions in the VS, IAW inputs received from Flight Test Campaign.
Upper T/B Fairing (TBC)	Possible innovative materials and manufacturing processes: • Out-of-Autoclave • High module thermoplastics Reduction of production time, single parts and part fixations Resistance to high in-service temperatures	Reference dimensions: TBC/TBD-in terms of a developed surface approx. a Square surface of 1200mmx1200mm	▪ 1 specimen kit ready for flight-(If Need/If Apply). ▪ This topic is pending to Tail Shape selection (TBC)

(iii) Possible Manufacturing processes that currently are under evaluation for applying them into the single parts of these major parts-.

(**)The dimension Included in this Table are approximately. These values will be frozen during Preliminary Design.

Table 1. Tail Unit structural components manufactured by the Core Partner

The Core Partner will guide the Partner for the sub-assembly, assembly and transport tooling. The sub-assembly tooling for the most of the major parts (exception of Tail Boom-Leader) will be delivered to the CoP, and the assembly and transport tooling will be delivered to the Leader. Therefore the Leader will perform the subassembly of the Tail Boom (Demonstrator specimen and testing specimen) and the final assembly of the RF. CoP will perform the subassemblies for HS, VS and others (TBC). In accordance with this workload division all the secondary and management tooling relative to the subassembly, assembly and/or transportation tooling will be delivered at the CoP or the Leader facilities.

In general and for info, the conceptual design of every component of the Rotorless tail will be driven by the Leader while the detailed design; manufacturing and partial assembly (applicable) will be done by the CoP. A high level of concurrent engineering is required all along the project to coordinate design phases, manufacturing, system integration and assembly in “on – ground” and “in – flight” demonstrators. Therefore the same level of concurrent engineering is expected to be achieved between the Partner, the CoP and the Leader for the task to be done in common.

The final requirements and features needed for the Prototype Subassembly, Assembly and Transportation tooling will be provided by CoP IAW the Leader at the beginning of the project with the delivery of the Technical Specification for the Tooling.

The Partner will be supported by the CoP during the Prototype Tooling Design and Manufacturing phases. The Leader will support them if necessary.

The CoP will support the Partner with the following tasks:

- Design Trade-off Studies/Conceptual Studies.
- Material and Production Trade-off Studies for Production process selection.
- Perform Preliminary Design, Sizing and Documentation for Sub-Assemblies and Assemblies just after PDR.
- Test Plan Drafting.
- Assembly Trials Campaign.

The Partner shall:

- Propose the most suitable and innovative assembly process (saving time and energy) for the chosen technology of every Single Part. Each sub-assembly and the final assembly will require all the necessary toolings (jig, drill, lift, etc.) to produce a part in accordance with the drawings. The number of these “secondary tools” should be reduced by an innovative design of the prototype Assembly and Transportation tooling in order to achieve the already said targets in terms of time and energy reduction.
- Define and Manufacture Prototype Assembly Tooling means that will assure the full functionality of the Sub-Assemblies and the Final Assembly and, if needed, modify the design.
- Define and Manufacture Prototype Transportation Tooling that will assure the full transportability of the full assembled Tail unit IAW the technical specification for Rotorless Tail.
- Define and Manufacturing Prototype Assembly Tooling that will assure the demanded Quality of each part IAW Technical Specifications.
- Define and Manufacture of all the secondary and management tooling (drilling templates, locating

templates, work platform, slings, turning device, etc.) that will be necessary for the subassembly, assembly and transportation processes.

- Generate a tooling documentation in accordance with the Core Partner specification. This documentation will include, at least, geometrical definition and geometrical control of the tooling in line with the requirements laid down by the CoP. Work with geometrical verification means e.g. laser tracker.
- Delivery of the Prototype Assembly Tooling to the CoP and the Leader.
- Support the Set up in the CoP and the Leader facilities in appropriate transportation means.
- Modify the Prototype assembly tooling IAW possible single parts design modifications after the CDR. Impact limits of this kind of modification (if needed) will be negotiated.
- Follow up of the works performed by the Leader and the CoP until the end of the project.
- It will be appreciated and desirable if defined Prototype Toolings could simplify the assembly and transportation process, i.e. being more innovative than the current assembly process.
- The implementation in the Prototype Assembly and Transportation Tooling Design of innovative and low cost concepts in terms of Materials and Design processes will be appreciated.
- Identify and report at least the following information: RC, weight (if applicable), materials, manufacturing procedures, LCA data, etc., always establishing the study versus the current solutions applied in industry.

By other hand and in order to provide a clear view of the tasks and works to be done by Partner, the WBS for the HVE B4.1 Tail Unit for the LifeRCraft Demonstrator is enclosed.

The WBS shown in figure 2 provides a clear view of the work to be done by Partner in the frame of HVE_B4.1 project for LifeRCraft demonstrator.

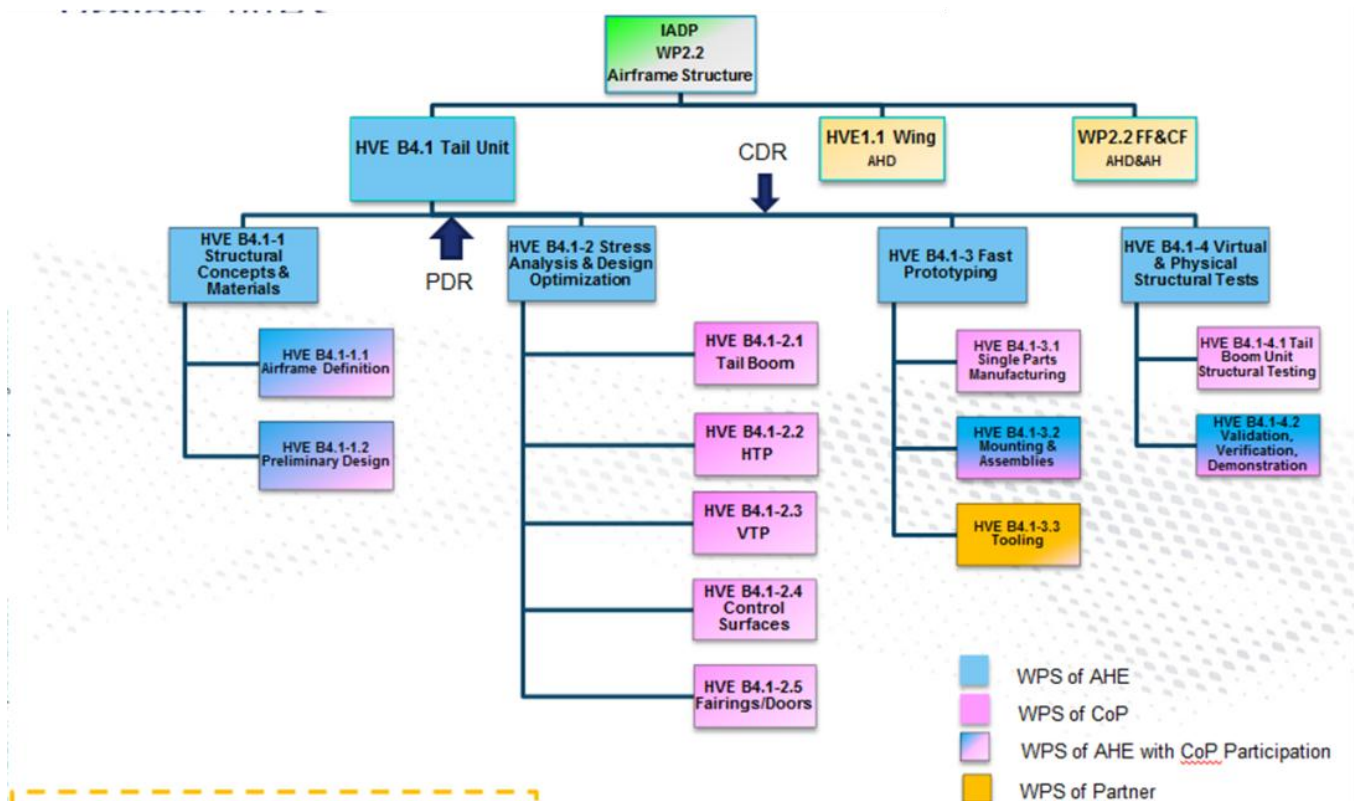
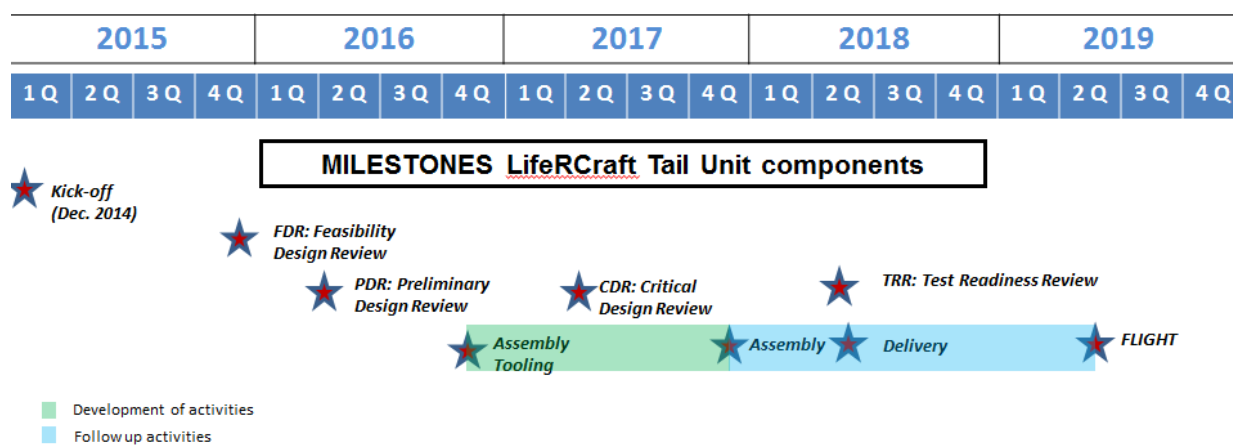


Figure 2. WBS for HVE_B4.1 Rotorless Tail for FastRCraft.

The Leader and CoP will provide the information (design documentation, general requirements specification, etc.) to the Partner IAW their roles and responsibilities to enable the Partner to perform all relevant tasks related to this CfP. In addition, permanent support to the partner by the CoP is envisaged. The following harmonization tasks have to be done before the start of the work:

- Method and Tool harmonization (substantiation, IT, Program management)
- Quality assurance process harmonization
- Communication management
- Content of substantiation file-if needed for prototype tooling.

3. Major deliverables/ Milestones and schedule (estimate)



Deliverables expected from Partner			
Ref. No.	Title – Description	Type	Due Date*
1	Inno.Prototype Assy-Transp. Tooling: - Prototype Jig & Tooling ready to assembly and transport the produced and assembled parts of the Rear Fuselage. - Quality inspection reports- CoC - Jig & Tooling Manufacturing Report - Prototype Jig & Tooling Maintenance and Working Orders.	Jig & Tooling Report Drawings Hardware	$T_0 + 13$
2	Inno. Prototype Assy-Transp. Tooling Assessments: - Assessment Reports for each Prototype Jig & Tooling about: ○ Trade off Report ▪ Materials and their manufacturing procedures (if apply), RC, Weight, LCA.... ○ Eco-design and Energy Consumption ○ Thermal Simulation Report - Final Report with Conclusions and Lessons Learned.	Report	$T_0 + 13$
3	Follow up Activities: - Design documents, 3D models, Jig & Tooling manufacturing reports etc... (Idem than Deliverable n°1&2) for possible modifications during follow up phase.	Jig & Tooling Report Drawings Hardware	$T_0 + 15$ until $T_0 + 32$

* T_0 Is the starting date of the activities to be performed by the applicant.

Inputs to be delivered by CoP and/or Leader to Partner			
Ref. No.	Title – Description	Type	Due Date*
1	Task for Leader and/or CoP-Technical documentation from Rotorless Tail PDR: - CATIA Models and drawings from PDR. - Tooling Technical Specification	Report Drawings	T_0
2	Manufacturing Processes: - Proposed materials (CoP) and manufacturing processes	Report	T_0
3	Task for Leader and/or CoP-Technical documentation from Rotorless Tail CDR: - CATIA Models, drawings and reports from CDR.	Report Drawings	$T_0 + 09$

* T_0 Is the starting date of the activities to be performed by the applicant.

4. Special skills, Capabilities, Certification expected from the Applicant(s)

(M) – Mandatory; (A) – Appreciated

- Experience in design and manufacturing of assembly tooling for structures in non-conventional and conventional composite materials (thermoset and thermoplastic –regular and high temperature conditions-) and innovative metallic components (A.)
- Design and analysis tools of the aeronautical industry: i.e. CATIA v5 r21 (M), NASTRAN (M), VPM (M) and Windchill (A).
- Experience in management, coordination and development technological (Aeronautical) programs. (M)
- Proved experience in collaborating with reference aeronautical companies with industrial air vehicle developments with “in – flight” components experience. (M)
- Participation in international R&T projects cooperating with industrial partners, institutions, technology centres, universities and OEMs (Original Equipment Manufacturer). (A)
- Competence in management of complex projects of research and manufacturing technologies. (A)
- Experience in the following fields (A):
 - Assembly
 - Process Automation
- Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004). (M)
- Regulated facilities for the use of laser in manufacturing process. (A)
- Capacity of providing tooling for large aeronautical components manufacturing within industrial quality standards. (M)
- Capacity to repair or modify “in-shop” the prototype assembly tooling due to manufacturing deviations. (A)
- Qualification as strategic supplier of manufacturing tooling on aeronautical elements. (A)
- Knowledge and experience in suitable technologies for aeronautical parts: positioning system, drilling, riveting and structural bonding. (M)
- Advanced Non Destructive Inspection (NDI) and tooling inspection like (A):
 - o Dimensional and shaping inspections
 - o Morphology studies of materials-if needed.
 - o Welding inspection
- Contactless dimensional inspection systems. (A)
- Simulation and Analysis of Tolerances and PKC/AKC/MKC (Product, and Manufacturing Key Characteristics). (A)
- Into the eco design field, the Partner shall have the Capability to monitor and decrease the use of hazardous substances regarding REACH regulation (M).

It is expected, that only technologies which are at TRL4 will be proposed for the prototype innovative assembly and transportation tooling. The above mentioned requirements will be fixed in more details during the partner agreement phase after selection. This will also include the IP-process.

5. Abbreviations:

TRL	Technology Readiness Level	M&A	Mounting and Assembly
OoA	Out of Autoclave	QG	Quality Gate
RTM	Resin Transfer Molding	R/C	Rotor Craft
SQRTM	Same Qualified Resin Transfer Moulding	RRs	Roles and Responsibilities
LRI	Liquid Resin Infusion	TBC	To Be Confirmed
IR	Infra Red	TBD	To Be Defined
XCT	X-ray Computerized Tomography	VS	Vertical Stabilizer
POA	Production Organization Approval	WBS	Work Breakdown Structure
DOA	Design Organization Approval	WP	Work Package
EASA	European Aviation of Safety Agency	COS	Conditions of Supply
FAA	Federal Aviation Administration	SPC	Super Plastic Forming
LCA	Life Cycle Analysis	ALM	Additive Layer Manufacturing
LCCA	Life Cycle Cost Analysis	AHE	Airbus Helicopters Spain
OEM	Original Equipment Manufacturer	CfP	Call for Partner
R&T	Research and Technology	CI	Configuration Items
NDI	Non Destructive Inspection	HS	Horizontal Stabilizer
IP	Intellectual Property	HVE	High Versatility and Cost Efficiency
CoP	Core Partner	IAW	In Accordance With
ISC	In-Situ Co-consolidation	ITD	Integrated Technology Demonstrator
TU	Tail Unit	JTP	Joint Technical Proposal
SMR	Structural Manufacturing Responsible	SDR	Structural Design Responsible
		CS	Control Surfaces

XV. Design Against Distortion: Part distortion prediction, design for minimized distortion, carbon-epoxy aerospace parts

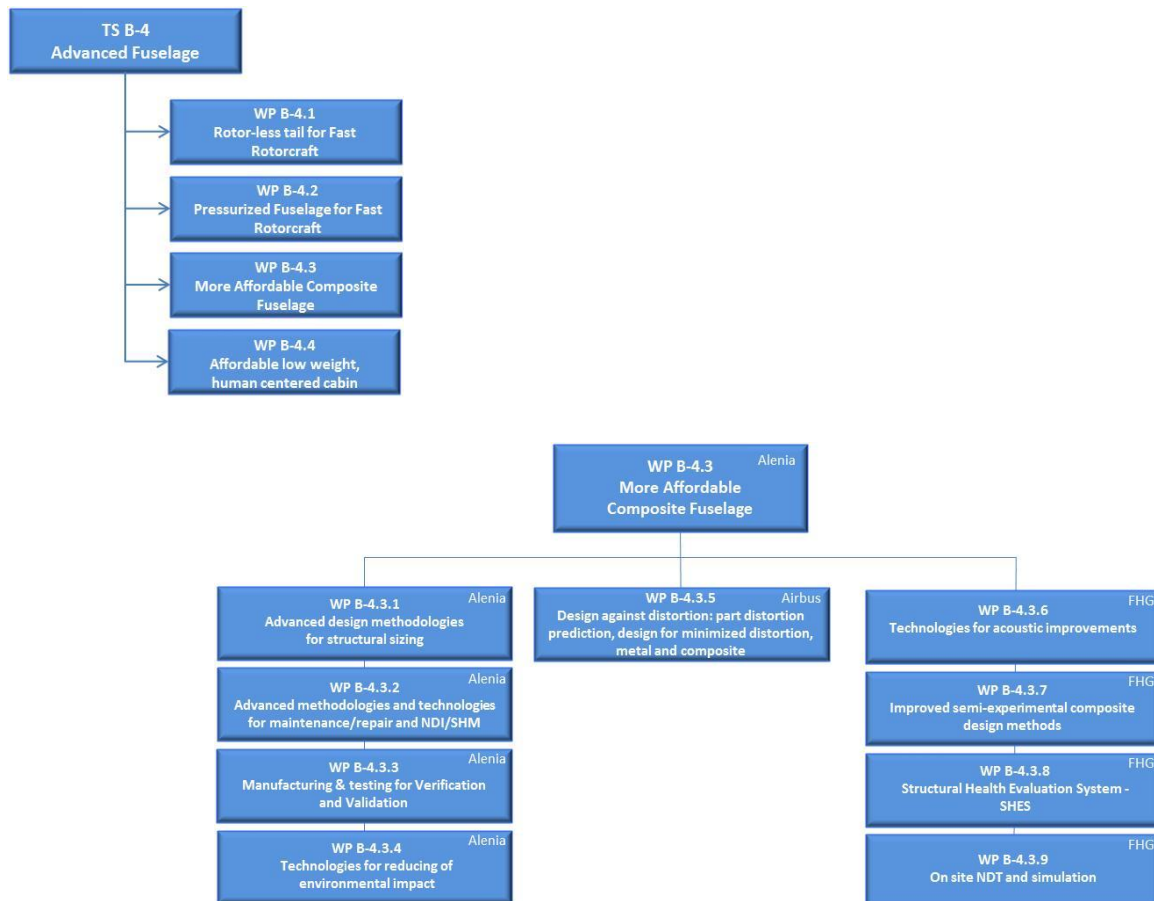
Type of action (RIA or IA)	RIA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	B-4.3		
Indicative Funding Topic Value (in k€)	345 k€		
Duration of the action (in Months)	30 months	Indicative Start Date⁴⁵	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-AIR-02-15	Design Against Distortion: Part distortion prediction, design for minimized distortion, carbon-epoxy aerospace parts
Short description (3 lines)	
Develop rapid distortion prediction methods for curing of carbon-epoxy. Develop methods & tools for shape- and layup optimisation accounting for distortion.	

⁴⁵ The start date corresponds to actual start date with all legal documents in place.

1. Background

Into the ITD Airframe part B, the call for proposal is linked to WP B-4.3 oriented to more affordable composite fuselage and specifically to WP B-4.3.5 on design against distortion topic as represented by the workbreakdown structure hereunder.



Distortion of aerospace parts is a significant burden on the European aerospace industry, in terms of recurring cost, and in terms of waste production / avoidable impact on the environment. Numerical modelling allows to foresee distortion issues and take corrective measures. These corrective measures are often not taken until a design is already in production. The number of “adjustable variables” is reduced at that stage. The *Design Against Distortion* Work-Package (WP) aims at developing a mean to take corrective action already during part design. In its most innovative form, this means having shape- and lay-up optimisation tools that account not only for the usual design criteria (buckling resistance, mechanical performance in general), but also for the risk of part distortion, and provide the basis for part designs that are more robust against distortion. “Robustness” in this context can mean two things:

1. Distorting very little;
2. Distorting always in the same, predictable way – irrespective of possible variations in material and processing.

The Work Breakdown Structure for this WP is given in Figure 25:

- The topic manager will contribute relevant uses cases, in collaboration with the CleanSkyII Demonstration Platform;
- Within the scope of this Call, partners will make distortion predictions and devise ways to exploit these in design;
- Towards the end of the work, the topic manager will demonstrate the new technology on the use cases – with support from the partners.

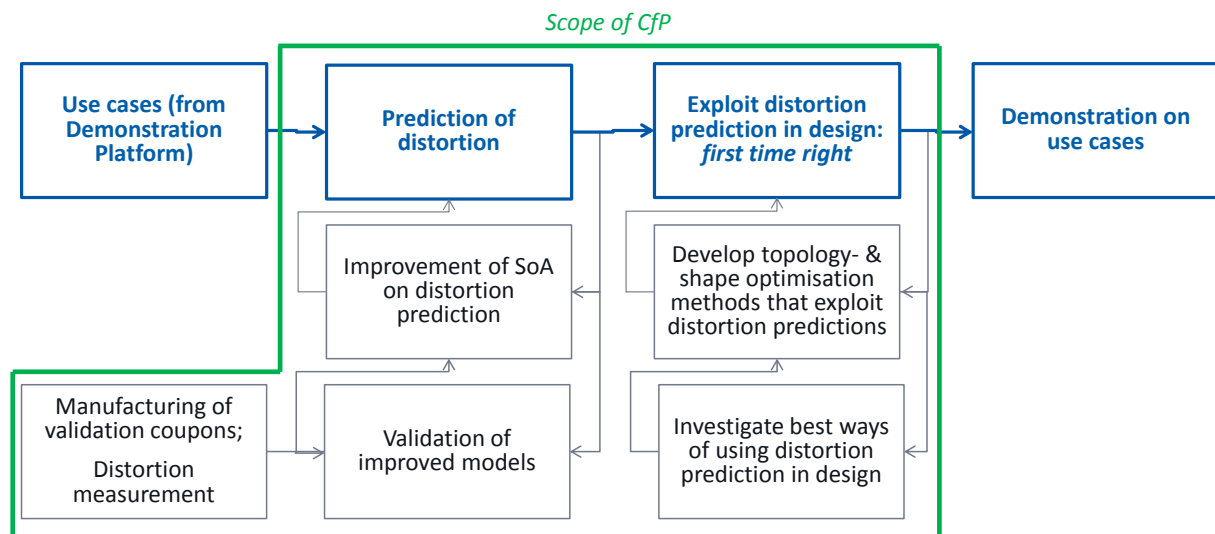


Figure 25: WBS

To perform these tasks, it will be necessary to develop sufficiently capable distortion prediction methods for the process of curing of thermoset carbon fibre reinforced epoxy. These must be validated against experiments on coupons. The coupons must be manufactured and their distortion measured accurately.

2. Scope of work

Tasks		
Ref. No.	Title – Description	Due Date
T1	Develop rapid distortion prediction methods for curing of thermoset composites	t0+18
T2	Shape and lay-up optimisation accounting for distortion	t0+30

T1

The manufacturing process of curing of carbon fibre reinforced epoxy resins is widely used in the aerospace industry and will remain so for many years to come. Distortion during and after the process is mainly due to differential thermal expansions (between fibres and resin, between tooling and part) and chemical shrinkage. Various research projects have already resulted in models to simulate the process and predict the distortion. In certain cases, it has even proven possible to predict the distortion in a simplified, rapid way, by simulating only the final cool-down with specially calibrated, “effective” coefficients of thermal expansion. Given the above, the following is called for here:

- Combine existing modelling approaches for the prediction of curing distortion in a rapid simulation such as the one described above, in order to obtain a versatile and rapid machining distortion prediction tool;
- Implement the combination, either in a widely used commercial software (e.g. CATIAv5; Abaqus) or an open source alternative (e.g. FreeCAD; CalculiX);
- Demonstrate predictive capability of the developed tool by applying it to at least two use-cases, then manufacturing those use-cases, measuring the distortion and comparing prediction with measurement. The use cases are to be selected in collaboration with the topic manager and will be parts with bounding-box dimensions less than 2 x 1 x 0.5 m and approximately 12 plies thick in one case, and at least 40 plies in the other.
- Express predicted risk of distortion in such a way that it can be used in topology optimisation (link with T2);

T2

Composite materials in theory allow extensive design freedom, however, lay-up “design rules” to avoid curing distortion and other manufacturing problems in effect greatly reduce the final design freedom. The activities asked to the applicant are as follows:

- Develop one or more methods to account for the risk / magnitude of part distortion during shape- and layup optimisation, using the rapid methods developed in T1. Interfacing with the tools used in T1 must be taken care of;
- Develop (a) prototype implementation(s) of these methods, preferably in an open source code (e.g. Python; FreeCAD; CalculiX; ...);
- Together with the topic manager, apply this (these) to at least one aerospace use-case.
- A recurring problem in today’s practice is the interfacing between Computer Aided Design (CAD) software, in which the initial geometry and layup are defined, and the tools for optimisation of shape and layup (Computer Aided Engineering tools, CAE). In order to efficiently treat the use-cases, a flexible solution to this problem must also be developed

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
<i>Ref. No.</i>	<i>Title – Description</i>	<i>Type</i>	<i>Due Date</i>
D1-1	Numerical model(s) for rapid predictions of curing distortion	Model	t0+12
D1-2	Curing distortion predictions	Report	t0+12
D1-3	Curing of distortion coupons and validation parts	Coupons	t0+12
D1-4	Distortion measurements cured coupons/parts	Report	t0+15
D1-5	Experimental validation of distortion prediction approach by comparison to measurements	Report	t0+18
D2-1	Efficient CAD to CAE interfacing method to import a design into an optimisation environment, initial geometry + initial ply definition, as a basis for subsequent shape- and layup optimisation.	Code (e.g. C, Python, ...)	t0+18
D2-2	Prototype shape- and layup optimisation code capable of accounting for risk of part distortion, as predicted by above models	Code (e.g. C, Python, ...)	t0+30

Milestones (when appropriate)			
<i>Ref. No.</i>	<i>Title – Description</i>	<i>Type</i>	<i>Due Date</i>
M1-1	Curing distortion prediction	Technology review	t0+9
M1-3	Curing distortion prediction	Validation review	t0+18
M2-1	Topology optimisation code capable of accounting for risk of part distortion, as predicted by above models	Technology review	t0+18
M2-2	Topology optimisation code capable of accounting for risk of part distortion, as predicted by above models	Technology review	t0+27

4. Special skills, Capabilities, Certification expected from the Applicant(s)

T1

Experience with non-linear simulation of composite materials and their processing. Access to the simulation codes mentioned in the call, and to trained staff employing them.

Capability to produce carbon-epoxy calibration coupons and small demonstrators (can also be sub-contracted, but in that case special care is needed to capture all of the relevant processing details for use in the simulation). Capability to accurately measure curing distortion.

T2

Experience with shape- and layup optimisation.

Notions of non-linear simulation of composite materials and their processing. Sufficient access to the simulation codes mentioned in the call, to ensure interfacing between rapid methods developed in T1 and optimisation code developed in T2.

XVI. Process development for composite frames manufacturing with high production rate and low cost

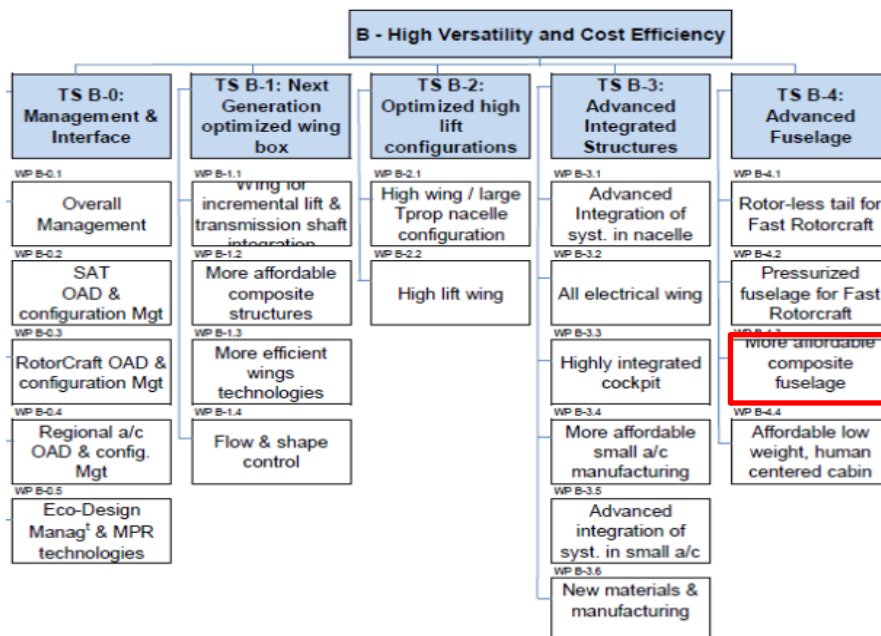
Type of action (RIA or IA)	IA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	WP B-4.3 – More affordable composite fuselage		
Indicative Funding Topic Value (in k€)	400 k€		
Duration of the action (in Months)	24 months	Indicative Start Date⁴⁶	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-AIR-02-16	Process development for composite frames manufacturing with high production rate and low cost
Short description (3 lines)	
The Topic shall contribute to the development and validation of an advanced process for manufacturing regional aircraft composite material fuselage frames, which will result in a significant reduction in overall production costs, component weight and manufacturing flow. The process shall be validated and costs assessed through the application of the building block approach from level 1 (coupons) to level 3 (sub-components) and to the realization of demonstrators.	

⁴⁶ The start date corresponds to actual start date with all legal documents in place.

1. Background

Activities to be performed according to the present Topic description are included in a wider context of work in the framework of the Airframe ITD of Clean Sky 2. In particular, the Work Package B-4.3 “More Affordable Composite Fuselage” is incorporated within the Technology Stream B-4 and represents the field where activities requested to the Applicant shall be performed. The relevant ITD Work Breakdown Structure is shown below, identifying WP B-4.3:



Furthermore, the activities of the WP B-4.3 will pursue the development of the technologies and methodologies already studied in the Clean Sky - GRA ITD domains and in other EU projects that addressed the feasibility of a composite fuselage for a Regional Turboprop aircraft. The objective is to drive the development of these technologies and methodologies to innovative solutions, which take into consideration drivers and factors indispensable for industrialization: increased structural integration, reduced total costs and structural weight, reduced environmental impact and extended aircraft life.

2. Scope of work

The scope of the present Topic is the development and validation starting from TRL 3 up to TRL 5 of an advanced manufacturing process for regional aircraft composite material fuselage frames which result in significant reductions in weight, overall production cost and manufacturing flow in order to demonstrate industrial feasibility.

Targets to be achieved compared to a reference metallic fuselage frame (sub-assy with shear ties included) are:

- 0-5% reduction of recurring costs;
- 5-10% reduction of weight;
- Production rate and total number of aircraft forecast at least equivalent.

To achieve these objectives, the main activities to be performed are synthetized in the following list:

- A trade in terms of cost, weight and production rate shall be performed among a set of pre-identified processes/materials/configurations;
- A Test Plan shall be defined to assess the main mechanical characteristics of materials, main point allowables for design, quality of the manufacturing trials and part repeatability;
- Tests shall be performed according to the Test Plan following the building block approach on designed and manufactured coupons, elements and sub-components;
- Demonstrators manufactured with the identified and set up process shall be provided.

The activities are divided in the tasks listed in the following table:

Tasks		
Ref. No.	Title - Description	Due Date
1	Process/material trade-off	T0 + 18
2	Test Plan definition	T0 + 11
3	Design of coupons, elements and sub-components	T0 + 15
4	Manufacturing of coupons, elements and sub-components	T0 + 19
5	Structural tests on coupons, elements and sub-components	T0 + 20
6	Manufacturing of structural demonstrators	T0 + 24

Task 1 - Process/material trade off

The advanced technologies development for composite frames for a Regional Turboprop aircraft shall be driven by the following key factors: increase of integration, reduction of manufacturing costs, reduction of assembling costs, increase of automation in manufacture and potentially in assembly, reduction of weight when compared to a traditional metallic frame.

The following processes shall be investigated:

1. Out of autoclave Liquid Resin Infusion (LRI);
2. Out of autoclave Resin Transfer Moulding (RTM).

In addition, the following integral frame configurations (directly connected to skin without shear ties) shall be

investigated:

1. "C" shape frame;
2. "Z" shape frame.

The above innovative configuration/process shall be compared in terms of weight, cost and production rate with the metallic reference solution of a floating frame made of an "L" shaped shear tie (connected to fuselage skin) and "C" shaped frame bolted to shear tie, having:

- Frame radius of approximately 1750 mm;
- Frame height of approximately 90 mm.

Further reference data (weight, cost and production rate) of the reference solution will be discussed at the Project kick off meeting.

An appropriate technology development phase shall be assessed for processes and relevant preliminary recurring cost estimation through dedicated manufacturing trials to be characterized in order:

- to assess process parameters;
- to verify part quality repeatability,
- to define a preliminary manufacturing plan and related costs.

The technology development plan shall include evidence of the necessary number and typology (geometrical characteristics & lay-up) of manufacturing trials to be manufactured and features to be characterized.

A preliminary design of all the innovative frame solutions under evaluation shall be carried out for weight estimation. Namely, data coming from activities related to "level 1" in tasks 2, 3, 4 and 5 (described below) shall be used for frame sizing.

The final trade-off results shall be an input in terms of material/process and configuration chosen for activities to be performed in the tasks 2, 3, 4, 5 (for "level 2" and "level 3") and task 6.

Task 2 - Test Plan definition

Maturation of the above-mentioned technologies shall be demonstrated by means of a test campaign. The Test Plan shall be defined following the building block approach covering the following levels:

1. Coupon level (Level 1) to be carried out for each material/process solution under evaluation in task 1;
2. Element level (Level 2: linear frame section - height about 90 mm; joint of linear frame sections - height about 90 mm;) to be carried out for the selected material/process solution in task 1;
3. Sub-component level (Level 3: sector of curved full scale frame - height about 90 mm, radius about 1750 mm) to be carried out for the selected material/process solution in task 1.

The Test Plan shall provide evidence of the required number and typology (geometrical characteristics & lay-up) of items to be tested for each of the mentioned level. In addition, the Test Plan shall be consistent with a Technology Readiness Level development from 3 up to 5.

Task 3 - Design of coupons, elements and sub-components

The 3 levels of items to be tested shall be designed for manufacturing and testing according to Test Plan

defined in Task 2.

- Level 1 panels with different representative thicknesses shall be designed for the respective coupons extraction and material characterization.
- Level 2 most critical structural details representative of a composite frame shall be designed for manufacturing and testing.
- Level 3 full scale representative sub components shall be designed for manufacturing and testing.

Design of level 2 and 3 structural items shall take into account requirements and input coming from Task 1 in terms of increase of integration, reduction of total costs, increase of automation in manufacturing and potentially in assembling, and weight reduction.

Task 4 - Manufacturing of coupons, elements and sub-components

Coupons, elements, subcomponents designed in Task 3 shall be manufactured in the present Task. Ultrasonic Non Destructive Inspections (NDI) shall be carried out for each manufactured item.

All fabricated structural items shall take into account development activities of task 1 on manufacturing trials.

Task 5 - Structural tests on coupons, elements and sub-components

Manufactured coupons, elements, subcomponents shall be tested taking into account particular sizing requirements.

Tests shall include for reference:

- Level 1-
 - mechanical tests (standard tension, compression and shear, open hole compression, filled hole compression, open hole tension and filled hole, bearing, compression and tension after impact, interlaminar shear strength, interlaminar tensile strength, pull through);
 - chemical-physical tests (resin chemical properties, laminate physical properties);
- Level 2 - tension, compression, shear for each detail;
- Level 3 - bending (at least, 3 critical load conditions).

All experimental data and correlated results analyses shall be included in Test Reports.

Task 6 - Manufacturing of structural demonstrators

Two full scale frame sectors (height about 90 mm, radius about 1750 mm, length about 2000 mm) shall be fabricated to validate the process, manufacturing costs and weight estimation.

The first manufactured item (PPV - Pre Production Verification) shall be destructively characterized in order to verify internal quality (defects not visible to NDI) and freeze process parameters.

Final demonstrator and its manufacturing report (containing process details) shall be provided at the end of the Task as well as final weight assessment and recurring cost evaluation for industrial production with indication of number and type of equipment needed to achieve the target rate.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title – Description	Type	Due Date
D1.1	Technology Development Plan for manufacturing trials and preliminary cost estimation	Report	T0 + 2
D1.2	Manufacturing trials to be characterized to assess process parameters for technologies/configurations under trade	Hardware	T0 + 9
D1.3	Configuration/process selection and preliminary cost/weight estimation trade-off report	Report	T0 + 10
D1.4	Manufacturing trials to be characterized to verify part quality repeatability and assess the processes for level 3 item fabrication	Hardware	T0 + 18
D2.1	Test Plan for level 1	Report	T0 + 2
D2.2	Test Plan for level 2 and 3	Report	T0 + 11
D3.1	Designed coupons, elements and sub-components	Report + CAD + FEM	T0 + 15
D4.1	Manufactured coupons, elements and sub-components	Hardware	T0 + 18
D4.2	NDI reports for coupons, elements and sub-components	Report	T0 + 19
D4.3	Manufacturing reports for coupons, elements and sub-components	Report	T0 + 19
D5.1	Coupons, elements and sub-components test reports and results analysis	Report	T0 + 20
D6.1	Design of full scale sector composite frame demonstrator	Report + CAD + FEM	T0 + 21
D6.2	First full scale demonstrator (PPV) characterization	Report	T0 + 23
D6.3	Manufactured final full scale composite frame sector demonstrator	Hardware	T0 + 24
D6.4	Final manufacturing and cost/weight assessment report	Report	T0 + 24

Milestones (when appropriate)			
Ref. No.	Title - Description	Type	Due Date
M1	Configuration/process selection and preliminary cost/weight estimation trade-off	Report	T0 + 10
M2	Manufactured coupons, elements and sub-components	Hardware	T0 + 18
M3	Final manufacturing and cost/weight assessment	Report	T0 + 24



4. Special skills, Capabilities, Certification expected from the Applicant(s)

- Skill 1: Proven competence in design and stress analysis of aeronautical composite structural components by a documented experience in participating in actual aeronautical programme design phase.
- Skill 2: Proven experience in manufacturing of composite full scale substructures for actual aeronautical programmes.
- Skill 3: Proven experience on non-destructive inspections. Evidence of NDI qualification shall be provided.
- Skill 4: Proven experience in experimental testing from coupon levels up to aeronautical full scale substructures. Evidence of qualification/certification of laboratories shall be provided.
- Skill 5: Proven experience in cost estimation at industrial level for aeronautical full scale composite structures.

1.5. Clean Sky 2 – Engines ITD

I. Conventional and Smart Bearings for Ground Test Demo

Type of action (RIA or IA)	IA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP 2 – Ultra High Propulsive Efficiency		
Indicative Funding Topic Value (in k€)	2000 k€		
Duration of the action (in Months)	66 months	Indicative Start Date ⁴⁷	Q2 2016

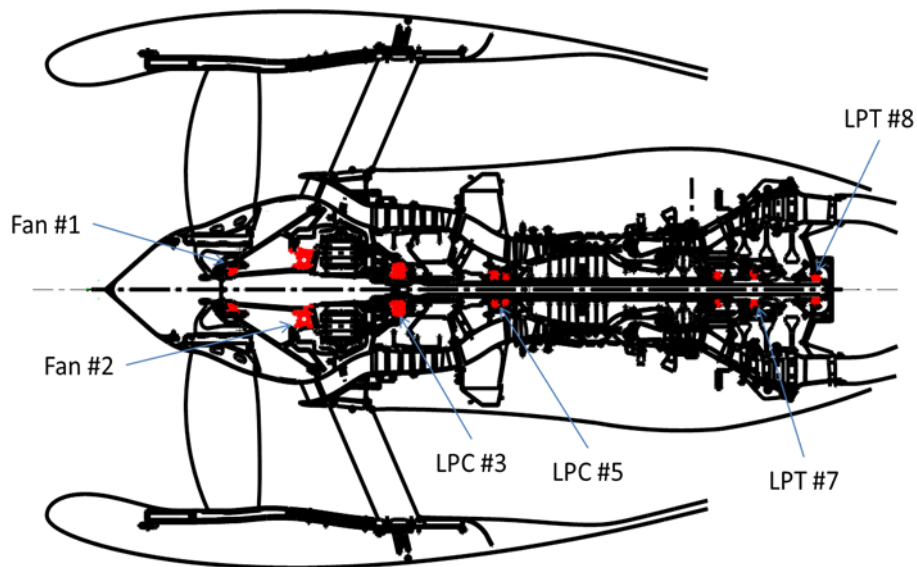
Identification	Title
JTI-CS2-2015-CFP02-ENG-01-02	Conventional and Smart Bearings for Ground Test Demo
Short description	
Supply all bearings of UHPE Ground Test Demo including current definition products and specific products that will be necessary due to the characteristics of UHPE Ground Test Demo. Innovative design is required in order to meet demo specification and to provide significant weight savings and room benefit versus existing standards.	

⁴⁷ The start date corresponds to actual start date with all legal documents in place.

1. Background

The UHPE Demonstration Project aims at designing, manufacturing & testing an Ultra High Propulsion Efficiency Engine Demonstrator. It involves most of the European Engine & Engine Modules & Sub-systems Manufacturers.

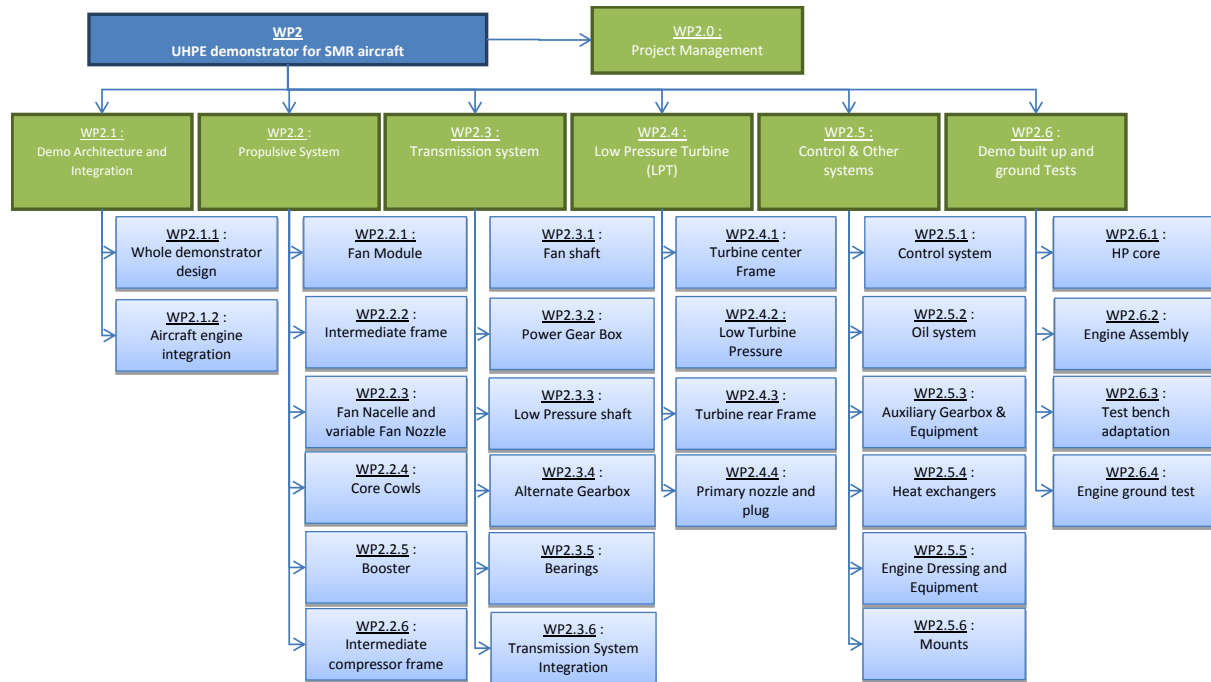
The UHPE demonstrator will have 8 bearings with 6 of them in the new LP parts.



With :

- Fan Rotor Bearings (1 & 2)
- Low Pressure Compressor (3 & 4)
- low Pressure Turbine (7 & 8)

The breakdown in this WP2 is the following :



2. Scope of work

The partner will provide a complete set of conventional bearings for the demonstrator plus a set of spare, and will deliver at least one smart bearing for the demonstrator.

For each bearing position, the conventional bearing and the corresponding smart bearing have to be interchangeable.

Test bench and test campaign at bearing level are requested) in order to mitigate risk before implementing bearings on engine module and engine.

Six bearings and their spares will be provided by the applicant :

- Fan Rotor Bearings (1 & 2)
- Low Pressure Compressor (3 & 4)
- low Pressure Turbine (7 & 8)

Bearings are specified in WP 2.1.1, a specific risk reduction plan has to be defined and is conducted in WP2.3.5. Bearings (conventional and smart) are designed and manufactured and matured (if needed) in WP2.3.5, assembled within the transmission system module in WP2.3.6, assembled with the engine in WP2.6.2 and tested in WP2.6.4.

Smart bearing will be able to deliver, in real time, information on bearing main functional characteristics and bearing health: temperatures, axial & radial load, ball or roller or cage speed, lubrication quality indicator, radial clearances, premise of failure on each part of the bearing.

Smart bearing will be autonomous for energy supply, storage, calculation and data will be transmitted wirelessly to the monitoring system, at least 1 time per second. Smart function will have a limited impact on bearing size and weight. The Classical requirements for the bearing design will be provided.

DIAGRAMME GANT - UHPE - cfp Bearings				2016		2017		2018		2019		2020		2021					
REF	Label	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	CFP MOUNTS																		
T0	Smart and conventional Bearings – Management and reporting																		
T1	Smart Bearings - Risk reduction plan																		
M1	Smart Bearings - Risk reduction plan review																		
M5	Smart Bearings - Risk reduction plan : Completion review																		
T2	Bearings – Requirements																		
M2	CS2/WP2 - D1 : Specifications																		
T3	Smart Bearings - Bearing monitoring system architecture																		
T4	Smart and conventional Bearings - Preliminary design																		
M3	CS2/WP2 - M2 : PDR																		
T5	Smart and conventional Bearings - Detailed design																		
M4	CS2/WP2 - M3 : CDR																		
T6	Smart Bearings – Justification of reliability of smart bearing technology for ground test demonstrators.																		
T7	Smart and conventional Bearing – Hardware delivery for demo engine																		
T8	Smart and Conventional Bearing - performance evaluation on demonstrator ground test																		
M6	CS2/WP2 - D2 : engine & bench ready for ground tests																		
TRL							3				4							5	

Tasks		
Ref. No.	Title – Description	Due Date
Task 0	<u>Smart and conventional Bearings – Management and reporting</u> Progress Reporting & Reviews: - Quarterly progress reports in writing shall be provided by the partner, referring to all agreed work packages, technical achievement, time schedule, potential risks and proposal for risk mitigation. - Monthly coordination meetings shall be conducted via telecom. - The partner shall support reporting and agreed review meetings with reasonable visibility on its activities and an adequate level of information. - The review meetings shall be held at the topic manager's facility. General Requirements: - The partner shall work to a certified standard process.	T0 + 66 months
Task 1	<u>Smart Bearings - Risk reduction plan</u> To provide and achieve a plan including test and capability demonstration for each technical element (Sensors/power supply/ data management (transmission & storage)/algorithms).	T0 + 36 months
Task 2	<u>Bearings – Requirements</u> To contribute to the UHPE demonstrator bearings and smart bearings requirements, written under SNECMA leadership.	T0 + 6 months
Task 3	<u>Smart Bearings - Bearing monitoring system architecture</u> To propose and finalise a system architecture including sensors/power supply/ data management (transmission & storage)/algorithms to monitor the bearings behavior	T0 + 12 months
Task 4	<u>Smart and conventional Bearings - Preliminary design</u> To perform preliminary design of UHPE smart and conventional Bearings complying with the specifications provided by WP2.1.1	T0 + 18 months
Task 5	<u>Smart and conventional Bearings - Detailed design</u> To perform detailed design of UHPE smart and conventional Bearings complying with the specifications provided by WP2.1.1	T0 + 30 months
Task 6	<u>Smart Bearings – Justification of reliability of smart bearing technology for ground test demonstrators.</u> To provide justification documents for the CDR, including results of risk reduction plan	T0 + 33 months
Task 7	<u>Smart and conventional Bearing – Hardware delivery for demo engine</u> To manufacture and deliver - At least one smart bearing and spares, - A set of conventional Bearings and spares, complying with the specifications provided by WP2.1.1	T0 + 39 months
Task 8	<u>Smart and Conventional Bearing - performance evaluation on demonstrator ground test</u> To perform partial Test of Smart and Conventional Bearing and to support for ground test of UHPE demonstrator complying with the specifications provided by WP2.1.1 .	T0 + 66 months

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title – Description	Type (*)	Due Date
D1	<u>Smart and conventional Bearings management plan</u>	R	T0 + 2 months
D2	<u>Smart Bearings - Risk reduction plan</u> <u>Intermediate status - Test Report</u>	R and RM	T0 + 3 months
D3	<u>Bearings – Requirements</u>	R and RM	T0 + 6 months
D4	<u>Smart Bearings - Bearing monitoring system architecture</u>	R and RM	T0 + 12 months
D5	<u>Smart Bearings - Risk reduction plan completion –Test Report</u>	R	T0 + 36 months
D6	<u>Smart and Conventional Bearings - PDR</u>	R and RM	T0 + 17 months
D7	<u>Smart and Conventional Bearings - Detailed design</u> Delivery of CAD files	D	T0 + 30 months
D8	<u>Smart Bearings – CDR</u>	R and RM	T0 + 30 months
D9	<u>Smart and Conventional Bearing – Hardware delivery</u> Smart bearings : At least one smart bearing and spares Conventional bearings : A set of conventional Bearings and spares	D	T0 + 39 months
D10	<u>Performance evaluation on demonstrator ground test (smart and conventional bearing) - final report and synthesis</u>	R and RM and D	T0 + 66 months

*Type: R: Report - RM: Review Meeting - D: Delivery of hardware/software

Milestones (when appropriate)			
Ref. No.	Title – Description	Type	Due Date
MS 1	<u>Smart Bearings - Risk reduction plan review</u>	RM	T0 + 2 months
MS 2	<u>CS2/WP2 - D1 : Specifications</u>	RM	T0 + 6 months
MS 3	<u>CS2/WP2 - M2 : PDR</u>	RM	T0 + 18 months
MS 4	<u>CS2/WP2 - M3 : CDR</u>	RM	T0 + 30 months
MS 5	<u>Smart Bearings - Risk reduction plan Completion review</u>	RM	T0 + 36 months
MS 6	<u>CS2/WP2 - D2 : engine & bench ready for ground tests</u>	RM	T0 + 49 months

4. Special skills, Capabilities, Certification expected from the Applicant(s)

- Experience in design, manufacturing, testing and certification of aircraft engine bearings is mandatory
- Experience in dynamic and engine vibration complex environment analysis is mandatory
- Experience in endurance tests or other relevant tests contributing to risks abatement is mandatory
- Availability of test benches to support test campaign is mandatory
- English language is mandatory

II. More electric, advanced hydromechanics propeller control components

Type of action (RIA or IA)	IA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP3		
Estimated Topic Value (funding in k€)	250 k€		
Duration of the action (in Months)	36 months	Indicative Start Date	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-ENG-01-03	More electric, advanced hydromechanics propeller control components
Short description (3 lines)	
The project aims at designing, manufacturing and testing more electric propeller control components, including propeller governor and oil pump, in order to optimize the overall propulsive efficiency.	

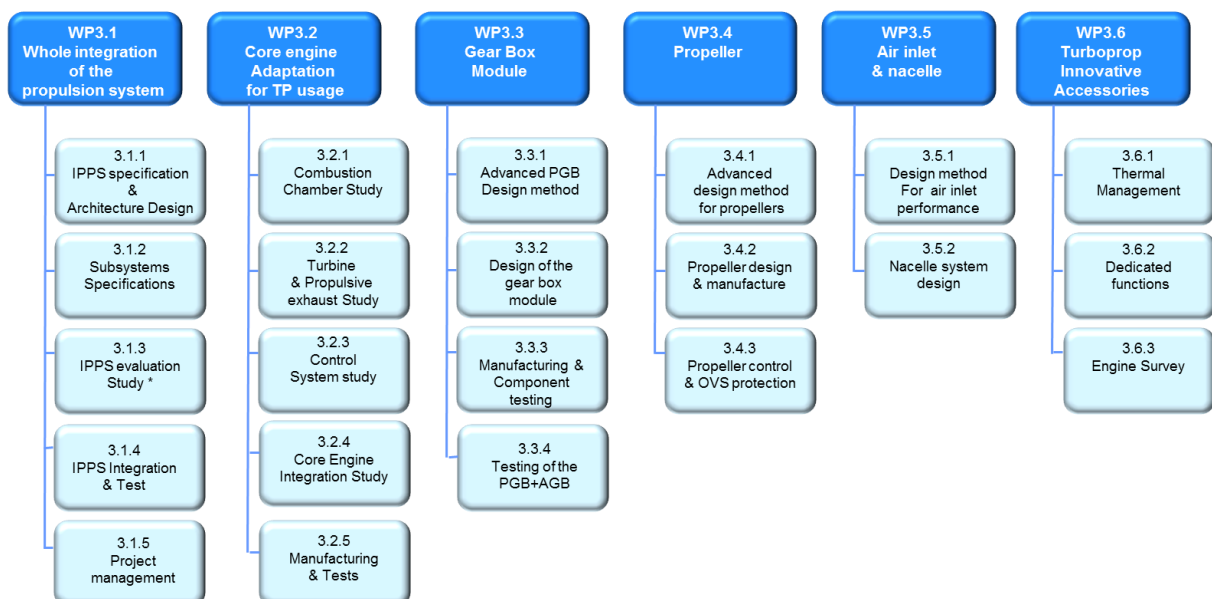
1. Background

WP3 targets the acquisition of technologies for a high performance turboprop in the 1800-2000 shp class which will significantly upgrade the actual product efficiency. This demonstrator will deliver technologies maturity up to TRL 5/6 in 2019 with capability to be part of the next generation of aircrafts.

The base line core of ARDIDEN3 engine will be improved specifically for turboprop application and then integrated with innovative gear box, new air inlet and innovative propeller and controls.

In this frame, the propeller control system incorporates more electrical components in order to improve propulsive efficiency and noise, weight, interface to aircraft and maintenance actions.

The figure below shows the project structure. The partner is expected to work within work packages WP3.4.3. He will also be involved in the workpackage WP3.1.4.



2. Scope of work

Turboprops in the 1800-2000 shp class are currently controlled by hydromechanical components. The equipments generally allow a maximum of 2 different propeller speeds; they are mechanically connected for pitch control and the oil pressure is provided by a mechanically driven oil pump.

The partner will be responsible for designing, manufacturing and testing advanced components for propeller control: propeller control unit, overspeed governor and oil pump, that will be tested at Turbomeca ground test facility.

- The propeller control unit will be based on hydromechanical control (flyweights and beta valve), but will integrate electric actuation for speed target and pitch target. It will also allow synchronizing
- The overspeed governor will be based on hydromechanical control, with electrical overspeed test and feathering. It will be compatible with the propeller control unit.
- The electrical oil pump will be powered with 28VDC, and commanded with a low power input from the engine and propeller computer.

The partner will also be responsible for delivering a dynamic model of each of the components, allowing Turbomeca to design and tune engine control laws. The software used shall be Simulink.

Finally, the partner will support Turbomeca during engine tests preparation and execution.

Tasks		
Ref. No.	Title - Description	Due Date
	T0	June 2016
Task 0	Project management and reporting	T0+36
Task 1	Concept studies (with TM)	T0+2
Task 2	Contribution to specifications (with TM)	T0+3
Task 3	Preliminary design	T0+10
Task 4	Detailed design	T0+12
Task 5	Production & functional tests	T0+20
Task 6	Support during engine tests	T0+30
Task 7	Environmental tests	T0+30
Task 8	Components dynamic models	T0+12

3. Major deliverables and schedule (estimate)

Deliverables & Milestones			
Ref. No.	Title - Description	Type (*)	Due Date
D1	Specifications (contribution of partner and TM)	R	T0+3
D2.1	Preliminary dynamic models	D	T0+6
D2.2	Final dynamic models	D	T0+12
D3	Preliminary Design Review	RM	T0+10
R4	Critical Design Review	RM	T0+12
D5	Equipments delivery	D	T0+20
R6	TM engine tests preparation	RM	T0+22
D7	Component tests reports (including environmental tests)	R	T0+34

* Type: R: Report - RM: Review Meeting - D: Delivery of hardware/software

4. Special skills, Capabilities, Certification expected from the Applicant

- EN 9100
- EASA PART 21
- Experience in design, manufacture, testing and certification of aircraft propeller controller and overspeed governors
- Experience in electrical actuators
- Experience in dynamic system modelisation
- English or French language

III. Engine Mounting System (EMS) for Ground Test Turboprop Engine Demonstrator

Type of action (RIA or IA)	IA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP3		
Indicative Funding Topic Value (in k€)	400 k€		
Duration of the action (in Months)	60 months	Indicative Start Date ⁴⁸	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-ENG-01-04	Engine Mounting System (EMS) for Ground Test Turboprop Engine Demonstrator
Short description	
Design, manufacture, assembly and instrumentation of an Engine Mounting System for Business Aviation / Short Regional TP ground demonstrator. EMS Set for characterization and validation during engine ground tests.	

⁴⁸ The start date corresponds to actual start date with all legal documents in place.

1. Background

WP3 targets the acquisition of technologies for a high performance turboprop engine in the power class below 2000 thermal shp. This demonstrator will deliver technologies maturity up to TRL 5/6 in 2019 with capability to be part of the next generation of aircrafts.

The base line core of ARDIDEN3 engine will be improved specifically for turboprop applications and then integrated with innovative gear box, new air inlet and advanced propeller.

The TP demonstrator will be installed at Turbomeca ground test facility. An Engine Mount System (EMS) must be designed and manufactured in order to connect the engine to the engine cradle.

The location for fitting points is shown in figure 1. The WP3 breakdown structure is shown in figure 2.

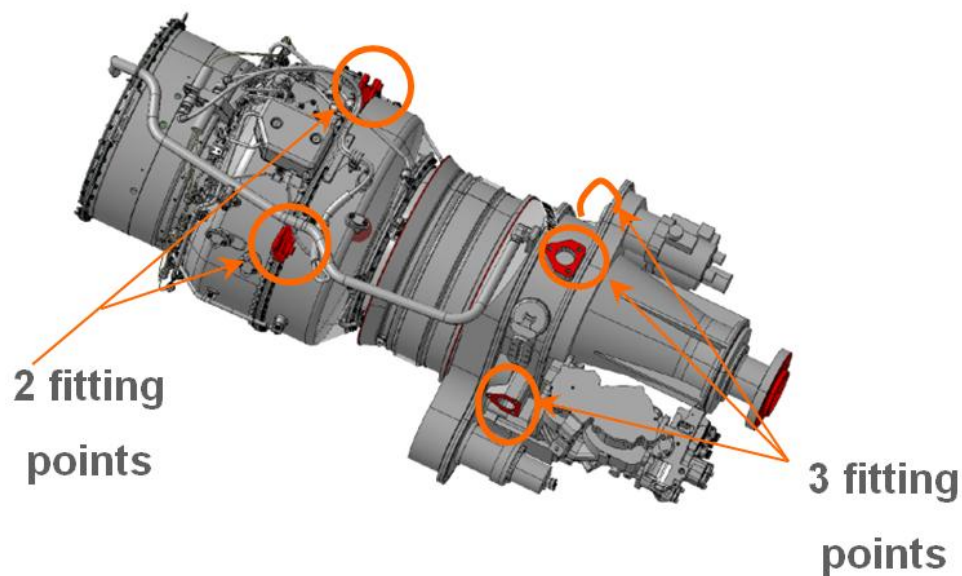


Figure 26: Illustration of Engine fitting points

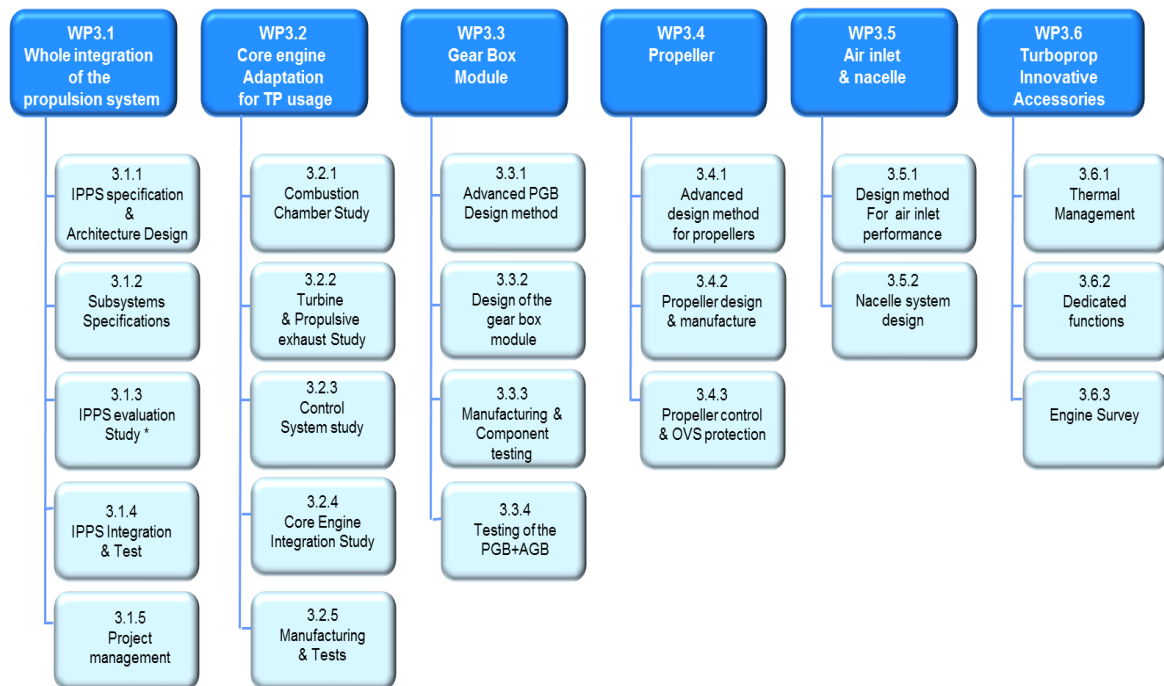


Figure 27: WP3 Workbreakdown structure

2. Scope of work

The scope of work of this CfP covers the perimeter of the Engine Mounts System. The applicant is required for participating in up-stream tasks as concept selection and EMS specifications ; in this phase, the interfaces between Aircraft and Engine will be defined, using the previous experience of the Engine Manufacturer and the Mount System Manufacturer.

After release of the specifications of the engine mounts, the applicant will design and manufacture the EMS for the engine ground tests.

The instrumentation will be agreed between the applicant and the engine manufacturer.

This Engine Mount System will be hyperstatic. In particular,

- The engine mounts must be designed to withstand propeller loads that are applied.
- The filtering must be studied to optimize the structural vibrations levels transmitted to the airframe (passenger cabin noise).
- The shock mounts must be designed to correctly interface with the engine casing (propeller gearbox and rear turbine casings)

Preliminary study must be performed to define the suitable design (damping and stiffness). A theoretical model of the damper must be provided early in the project to be integrated into the Whole Engine Model (WEM) for analysis.

The filtering will be measured at ground test facility to verify the accuracy of the models.

Two iterations on the engine mount designs may be necessary for global optimization.

Tasks		
Ref. No.	Title - Description	Due Date
Task 0	<u>Engine Mount System – Management and reporting</u> Progress Reporting & Reviews: - Quarterly progress reports in writing shall be provided by the partner, referring to all agreed workpackages, technical achievement, time schedule, potential risks and proposal for risk mitigation. - Monthly coordination meetings shall be conducted via telecom. - The partner shall support reporting and agreed review meetings with reasonable visibility on its activities and an adequate level of information. - The review meetings shall be held at the topic manager's facility. General Requirements: - The partner shall work to a certified standard process	T0 + 58 months
Task 1	<u>Engine Mount System – Concept studies</u> Final report of various EMS Concept studies, including improvements proposals based on test results	T0 + 56 months
Task 2	<u>Demonstrator EMS – Contribution to specifications</u>	T0 + 1 months
Task 3	<u>Demonstrator EMS – Preliminary design of mounts</u> To perform preliminary design of EMS	T0 + 12 months
Task 4	<u>Demonstrator EMS – Detailed design of mounts</u> To perform detailed design EMS complying	T0 + 24 months
Task 5	<u>Demonstrator EMS – Parts delivery of mounts</u> To manufacture and deliver EMS	T0 + 30 months
Task 6	<u>Demonstrator EMS – test report of mounts behavior</u> - To perform partial Test of_Component Test EMS_and to support for ground test of UHPE demonstrator EMS complying with the specifications provided by WP2.1.1 . - To issue reports of these tests for EMS.	T0 + 48 months

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type (*)	Due Date
D1	<u>Mount system preliminary design substantiation & hypothesis for Preliminary design review</u> To check the feasibility and to freeze the architecture and interfaces, to identify the validation plan	R	T0 + 1 month
D2	<u>Mount system detailed design substantiation document for the critical design review</u> Design Freeze to start hardware manufacturing	R	T0 + 3 months
D3	<u>Mount system hardware delivery</u> Availability at TM of hardware	D	T0 + 9 months
D4	<u>Optimized Mount system detailed design substantiation document for the critical design review</u> Design Freeze to start second set of hardware manufacturing	R	T0 + 16 months
D5	<u>Optimized mount system hardware delivery</u> Availability at TM of hardware	D	T0 + 22 months
D6	<u>Engine readiness review documentation:</u> • <u>Delivered Hardware status compared</u> • <u>Instrumentation</u> • <u>Test plan requirements</u> Contribution to engine test review	R	T0 + 36 months
D7	<u>Engine Ground test report for mount system</u> Contribution to the engine after-test review	R	T0 + 54 months

* Type: R: Report - RM: Review Meeting - D: Delivery of hardware/software

Milestones (when appropriate)			
Ref. No.	Title - Description	Type	Due Date
MS 1	<u>Mounts System : Preliminary Design Review</u>	RM	T0 + 1 month
MS 2	<u>Mounts System :Critical Design Review</u>	RM	T0 + 3 months
MS 3	<u>Second mounts System : Preliminary Design Review</u>	RM	T0 + 12 months
MS 4	<u>Second mounts System :Critical Design Review</u>	RM	T0 + 16 months
MS 5	<u>Mounts System : Engine Readiness Review</u>	RM	T0 + 24 months

4. Special skills, Capabilities, Certification expected from the Applicant(s)

- Experience in design, manufacturing, testing and certification of aircraft engine mounts is mandatory
- Experience in elastomeric dampers is mandatory
- Experience in dynamic and vibration engine complex environment analysis is mandatory
- Experience in test bench design and modification is mandatory
- Experience in endurance tests or other relevant tests contributing to risks abatement is mandatory
- English language is mandatory

IV. Integration of Laser Beam Melting Simulation in the tool landscape for process preparation of Additive Manufacturing (AM) for Aero Engine applications

Type of action (RIA or IA)	RIA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP4 Geared Engine Configuration		
Indicative Funding Topic Value (in k€)	700 k€		
Duration of the action (in Months)	36 months	Indicative Start Date⁴⁹	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-ENG-02-02	Integration of Laser Beam Melting Simulation in the tool landscape for process preparation of Additive Manufacturing (AM) for Aero Engine applications
Short description (3 lines)	
It is demonstrated that simulation of an additive manufactured engine part concerning residual stresses and distortions is possible. However the usually used models incorporate many simplifications and can therefore not model the complexity of real life parts and the AM-process. Results indicate that simulation of a number of equal or geometrically complex or big parts with supporting structures on the building platform may need several 100 hours of simulation time which is not applicable in terms of process optimization. The aim of this project is therefore to increase the fidelity of the predictions and decrease the calculation time dramatically by novel methods. Use of open software will ease user based extension/modification.	

⁴⁹ The start date corresponds to actual start date with all legal documents in place.

1. Background

First simple aero engine parts manufactured by AM-processes have successfully been introduced into series production. To make use of all benefits of the process like freedom in design, cost efficiency and time to market first time right production has to be achieved. Distortions after production are a major issue. In order to enable a first time right production a process development supported by manufacturing simulation is a promising option. Development projects in the field have shown that the complexity of the AM process needs a very detailed physics based modelling. Today known models are not able to handle this complexity in a reasonable computing time. Thus adequate surrogate modelling is a must to achieve high fidelity solutions.

2. Scope of work

Tasks		
Ref. No.	Title - Description	Due Date
WP 1	Management Organisation: The partner shall nominate a team dedicated to the project and should inform MTU Aero Engines 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 Aero Engines), Techniques & Quality. Time Schedule & Work package Description: - The partner is working to the agreed time-schedule & work package description. - Both, the time-schedule and the work package description laid out in this call shall be further detailed as required and agreed at the beginning of the project. Progress Reporting & Reviews: - Quarterly progress reports in writing shall be provided by the partner, referring to all agreed work packages, technical achievement, time schedule, potential risks and proposal for risk mitigation. - Regular coordination meetings shall be installed (preferred as telecon). - The partner shall support reporting and agreed review meetings with reasonable visibility on its activities and an adequate level of information. - The review meetings shall be held in MTU Aero Engines facility. General Requirements: - The partner shall work to a established standard process.	During the whole Project
WP 2	WP2 Using of open source codes for unrestricted functionalities - Definition of running environment and development framework (For example: OS, CAx-tools, data formats) - Realization of main functionalities in open source codes - Using advantage of user flexibility to be able to extend and adapt process specific user algorithms	T0+12M

Tasks		
Ref. No.	Title - Description	Due Date
WP 3	WP3 Digital data chain • Development of CAD based data chain for simulation of distortions • Use of simulated distortions for reengineering of the manufacturing design to reduce distortions in the manufactured part. • Development of a workflow for reengineering which works with measured or simulated distortions respectively in order to reduce the number of iterations and realize first time right manufacturing. Boundary condition: compatibility with established 3D formats (CAx)	T0+18M
WP 4	WP4 Acceleration of calculation time • Complex calculation tasks (fast transient problems, complex structures and high intensity of energy) lead to unacceptable simulation times • Acceleration of the simulation by for example parallel use of GPU and CPU, by efficiently adapted FE meshing and by selection of suitable FE solvers • Many and/or filigree structures can be simulated. Mutual influence between several parts on the platform and the build platform itself shall be included in the used model.	T0+15M
WP 5	WP5 Realization and validation of complex user defined laser exposure strategies • Detailed models need too much time for simulation. Therefore global models with reduced accuracy are used today. • Studies to examine how to transfer transient data fields from detailed physics based models to improved global models which combine many layers with the help of for e.g. library functions. • Studies securing constant energy input in relation to the local part geometry. Therefore it is necessary to use different exposure parameters in different part areas. • Development of concepts for simulation of distortion in case of AM machines with several laser sources or multiple exposure • Consideration of the influence of beam angle and laser profile	T0+21M
WP 6	WP6 Consideration of process step stress relief annealing • Development of a creep model to describe the stress relief annealing (Keep in mind: temperature range is essential for initial strength and state of precipitation of phases in microstructure) • Study on relevance of modelling of creep during build process • Implementation of a model for separating parts from the build platform in order to assess the final distortions after heat treatment and separation.	T0+27M

Tasks		
Ref. No.	Title - Description	Due Date
WP 7	WP7 Consideration of support structures in the simulation model - Inclusion of user-defined variable support structures and variable contact areas like full or partial contact - Provision of different support types. Especially material properties (Thermal and mechanical) of different support types have to be modelled. - Transfer of these support types to filigree structures like honey combs. - Review of necessary material characterizations (e.g. Properties of powder in case of closely neighbouring components / tight holes in the component or in case of support structures with different process parameters)	T0+30M
WP 8	WP8 Documentation and revision control system - Documentation and development of tutorials for the use of the simulation tools - Revision control system of software by common tools like SVN or CVS - User training	T0+36M

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type	Due Date
D2.1	M2.1 Framework is defined	R	T0+6M
D2.2	M2.2 All functionalities implemented in open source. User and process specific codes can be implemented.	R	T0+12M
D3.1	M3.1 Realization of the CAD based workflow. Reduction of height of steps of the surface contour produced by simulation	R	T0+18M
D3.2	M3.2 Reengineered model successful. Measured and simulated distortions can be used for reengineering (First time right manufacturing of AM parts)	R	T0+18M
D4.1	M4.1 Possibility of calculation of multiple components on building platform and mutual influence is demonstrated. Calculation time for a reference job is in the range or lower than building time.	R	T0+15M
D4.2	M4.2 Possibility of simulation of complex, filigree structures leading to very high FE element numbers is demonstrated.		
D5.1	M5.1 Data transfer between detailed and global model is realized and validated. (Evaluation of sensitivity of the assumption "combination of many layers" in the global model)	R	T0+21M
D5.2	M5.2 Possibility to optimize the local thermal history is shown. Optimization is based on local changes in heat flux caused by the geometry.		
D5.3	M5.3 Model for simulation of distortion in case of AM machines with several laser sources or multiple exposure developed.		
D6.1	M6.1 Creep mechanism can be modelled. Stress relief anneal process step of manufacturing chain can be calculated. Ability to evaluate remaining residual stresses after heat treatment (annealing) => potential / risk for increase or reduction of mechanical load capacity	R	T0+24M
D6.2	M6.2 Remaining distortions after heat treatment and separation from build platform can be calculated (incl. validation).	R	T0+27M
D6.3	M6.3 Study on relevance of creep during build process validated.	R	T0+27M
D7.1	M7.1 Demand on additional material characterization assessed. Dependent on the used model for filigree structures and interdependencies of powder/platform/part.	R	T0+9M
D7.2	M7.2 Material Characterization completed.	D	T0+18M
D7.3	M7.3 Demonstrator part with filigree structures, support structures and small holes/gaps is simulated/validated including all interdependencies.	D	T0+30M
D8.1	M8.1 Revision control system established.	R	T0+12M
D8.2	M8.2 Documentation and instructions for training are available and first user training done.	R	T0+36M

Types: R=Report, D-Data, HW=Hardware

Milestones (when appropriate)			
Ref. No.	Title - Description	Type	Due Date
M2.1	Framework is defined		T0 + 6M
M3.1	Reengineered model successful		T0 + 18M
M5.1	Model for simulation of distortion developed		T0 + 21M
M7.1	Material Characterization completed		T0 + 18M
M7.2	Demonstrator part fully simulated/validated		T0 + 30M

Types: R=Report, D-Data, HW=Hardware

Estimated schedule

	T0+3M	T0+6M	T0+9M	T0+12M	T0+15M	T0+18M	T0+21M	T0+24M	T0+27M	T0+30M	T0+33M	T0+36M	
WP1 Management													
WP2 Open source code													
WP3 Digital data chain													
WP4 Acc. of calculation time													
WP5 Laser exposure strategies													
WP6 Incl. of stress relief heat treatment													
WP7 Support structures													
WP8 Documentation													

4. Special skills, Capabilities, Certification expected from the Applicant(s)

- Detailed / very good understanding of the AM process
- Experience with simulation and manufacturing tools in the AM field
- Validated simulation models for nickel base superalloys from earlier studies
- Possibility to experimentally validate new models or new model inputs
- Possibility to analyze and combine different length and time scales of the AM process
- Experience with simulation in multi scale and multi physics tasks
- Experience with experimental investigations in the field of AM
- Willingness to give full insight into models, codes and development strategy

V. **Integration of a property simulation tool for integrated virtual design & manufacturing of forged discs/rotors for aero engine applications**

Type of action (RIA or IA)	RIA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP4 Geared Engine Configuration		
Indicative Funding Topic Value (in k€)	450 k€		
Duration of the action (in Months)	36 months	Indicative Start Date ⁵⁰	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-ENG-02-03	Integration of a property simulation tool for integrated virtual design & manufacturing of forged discs/rotors for aero engine applications
Short description (3 lines)	
Simulation of microstructural and mechanical properties for forged DA718 parts - considering billet, final part forming and heat treatment process route has been demonstrated.	
To increase prediction fidelity the next step is to include the aspect of grain structure originated in the beginning of the overall manufacturing process and its modification during the process route for DA718 in the model. Additionally impact of grain structure, i.e. degree of recrystallization, on mechanical properties including yield strength variations in circumferential direction shall be evaluated.	
Further development of the modelling backed-up with experimental validation work is required, covering the complete manufacturing process for forgings.	

⁵⁰ The start date corresponds to actual start date with all legal documents in place.

1. Background

Forging suppliers use standard forging simulation tools to develop the technological process (setting of forging parameters) for many years. Recently forging suppliers started to implement microstructural simulation plus mechanical property simulation.

Objective of this R&T activity is to provide a model/tool to simulate the microstructure and specific mechanical properties of forged turbine disks made out of DA718. This work shall take into account the variation in microstructure and mechanical properties in the forged part to evaluate the accuracy of the used model.

Variations in strength in circumferential directions are identified in forged turbine disks. The magnitude of these variations, referred to the respective radial positions, are currently not predictable. The metallurgical understanding of this phenomenon and a quantitative prediction is an important issue to be addressed within this project.

In order to develop a high fidelity model the microstructure variation of the forging stock (i.e. billet material) in the transverse and longitudinal direction shall be implemented in the model.

2. Scope of work

Tasks		
Ref. No.	Title - Description	Due Date
1.	Management Organisation: The partner shall nominate a team dedicated to the project and should inform MTU Aero Engines 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 Aero Engines), Techniques & Quality. Time Schedule & Work package Description: - The partner is working to the agreed time-schedule & work package description. Progress Reporting & Reviews: - Quarterly progress reports in writing shall be provided by the partner, referring to all agreed work packages, technical achievement, time schedule, potential risks and proposal for risk mitigation. - Monthly technical coordination meetings shall be installed (preferred as telecon). - The partner shall provide progress reporting and support agreed reviews to demonstrate results and achievements of activities at an adequate level of information. The review meetings shall be held in parts at the MTU Aero Engines facility.	During the whole Project
2.	A number of functional properties of a turbine engine disk is related to the billet. Therefore the applicant shall implement the full history of the microstructural evolution for the final rotor disk in the simulation model. This includes the variation in chemistry and grain size in circumferential and longitudinal direction in the billet. The applicant shall establish a close collaboration with the forging stock supplier to enable the simulation of the full process chain.	T0+10M

Tasks		
Ref. No.	Title - Description	Due Date
3.	<u>Microstructural modelling of nickel-based super-alloys</u> 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 shall develop and 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, under special considerations of duplex grain structures. The applicant shall have experience with physically motivated modelling of microstructure in order to extend such models to more complex phenomena like the direct aging process of IN718. Accuracy and uncertainty effects must be quantified and the range of applicability for the simulation method is well defined.	T0+16M
4.	<u>Modelling of material properties (yield strength, fatigue) relevant for materials with duplex grain size</u> The design methods rely on the prediction of material properties such as yield strength, low/high cycle fatigue which correlate with the materials' micro-structure resulting from forging and heat treatment. The applicant shall set up an advanced physically motivated computational modelling approach in order to predict the mechanical properties and their variation in radial and circumferential direction. The influence of non-uniform grain structures (i.e. duplex microstructures) on mechanical properties shall be evaluated. Yield strength and fatigue properties of DA718 are definitely the key attributes to be looked at. Accuracy and uncertainty effects must be quantified and the range of applicability for the simulation method is well defined. The expected simulation maturity level should allow significantly reduced testing and less iterations in engine component development	T0+22M

Tasks		
Ref. No.	Title - Description	Due Date
5.	<u>Validation of modelling results</u> The applicant shall provide correlations of cut-up with modelling results in regard of microstructure and mechanical properties. This shall include grain size, delta, gamma', gamma'' phases. Relevant analytic techniques shall be applied to address the different length scales in the verification, calibration and validation of the models. Due to variability in experimental input data, process boundary conditions, model non-linearity and physical complexity the envisioned simulation approach is inevitably probabilistic in nature. It is thus of paramount importance that the applicant is able to explain the metallurgical reasons for mechanical property variations in order to address and describe 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.	T0+26M

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type	Due Date
D2.1	Report on the quality of existing computational models and level of improvement	R	T0 + 6M
D3.1	Detailed approach and plan on how to develop the physically motivated computational microstructure model for prediction of functional properties	R	T0 + 12M
D4.1	Detailed approach and plan on how to develop the physically motivated computational model for prediction of material properties including the verification, calibration and validation activities	R	T0 + 22
D5.1	Hardware available (for cut-up testing)	HW	T0 + 18M
D5.2	Report of experimental validation of microstructure simulation	D	T0 + 24M
D5.3	Report of experimental validation of property simulation	D	T0 + 26M
D5.4	Final report incl. detailed description of the model, validation results and a fidelity assessment	R	T0 + 30M

Types: R=Report, D-Data, HW=Hardware

Milestones (when appropriate)			
Ref. No.	Title - Description	Type	Due Date
M1	Summary of existing computational models and identifying the principle approach to use		T0+8M
M2	Final Concept for model development and validation		T0+12M
M3	Cut-up testing report		T0 + 20 M
M4	Comparison of cut-up and prediction results – taking into account the variation in the mechanical properties and microstructure as well as the accuracy of the model		T0+24M
M5	Start final iteration for model validation		T0 + 30 M

Types: R=Report, D-Data, HW=Hardware

4. Special skills, Capabilities, Certification expected from the Applicant(s)

- Partner shall work to established standard processes shared and approved with MTU
- MTU Aero Engines approved supplier for class 1 (critical) parts (i.e. forgings for turbine engine rotating disks)
- Capability to involve certified material test houses for specimen tests.
- Certification: ISO 9001, EN9100, EN ISO 14001, NADCAP heat treating certificate, NADCAP non destructive testing certificate
- Project management competence in accordance to IPMA standards

VI. Industry focused eco-design

Type of action (RIA or IA)	RIA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP Level 1		
Indicative Funding Topic Value (in k€)	2500 k€		
Duration of the action (in Months)	48 months	Indicative Start Date⁵¹	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-ENG-03-01	Industry focused eco-design
Short description (3 lines)	
Develop an industry focused assessment tool to evaluate the environmental and sustainability impact of a product during its design. The tool will help aerospace efficiently manage the transition from low confidence early design data to more detailed assessments as part of existing design workflows.	

⁵¹ The start date corresponds to actual start date with all legal documents in place.



1. Background

There is a growing customer demand for Rolls-Royce and other aerospace organisations to supply life cycle environmental data for their products as a way of supporting the use of eco-design principles for a given product. Whilst we have made good progress in investigating the requirements for a capability that will integrate with our current workflows and have developed technical demonstrators for such, the industry needs to make significant advances in fully integrated systems to address the current and emerging requirement.

We are looking to partner with a company who can develop the current capability of the industry to a more advanced level by providing an integrated solution for assessing product level life cycle environmental impacts to support eco-design principles as a part of our existing workflows.

The system requirements will be provided by Rolls-Royce and other aerospace industries via our engagement with customers and aerospace trade organisations (such as ADS and IAEG).

We will provide examples and data on the workflows to be integrated with as well as research and support on life cycle and impact assessment into Rolls-Royce/gas-turbine products. We will also provide data and examples to verify all elements of the developed system.

The partner organisation will be required to take this information and data and produce a working tool that evaluates the environmental and broader sustainability, supply and legislative risk credentials of a design whilst maintaining a positive link to the properties that make the materials and processes used suitable for that application, linking to 'approved materials/process' information where needed to support decision making.

The tool will need to support current workflows and be able to cope with data gaps and low-confidence data, whilst supporting a seamless transition from early design to detailed design, reflecting the associated increases in data confidence that may become available.

2. Scope of work

Tasks		
Ref. No.	Title – Description	Due Date
Task 1	Requirement capture and specification definition: Completion of this task is linked to deliverable D1	T0 + 6 months
Task 2	Methodology development: Progress of this task is linked to milestone M1	T0 + 12 months
Task 3	Create demonstration software tool: Progress of this task is linked to milestones M2, M3 and M4	T0 + 36 months
Task 4	Test case validation: Progress of this task is linked to milestone M5	T0 + 42 months
Task 5	Finalise tool: Progress of this task is linked to milestone M6 . Completion of this task is linked to deliverable D2	T0 + 48 months
Task 6	Closing report and next steps: Completion of this task is linked to deliverable D3	T0 + 48 months

Task 1: Requirements capture and specification definition: Clarify with stakeholders the data and assessment requirements for evaluating eco-design credentials within the aerospace sector. Define workflow that the eco-design tools will need to support and associated requirements for seamless integration with existing in-house CAD and PLM tools.

Task 2: Methodology development: This will be split into the following areas:

- Early concept design assessment: The current SAMULET tool requires a reasonably well defined product life cycle in order to be able to calculate the life cycle environmental impacts. This project will enhance the assessment capability so that concepts that are very early in their development cycles can still be assessed, despite a lower confidence in the data.
- Uncertainty of data: Streamlined LCA has the benefit of being cheaper but tends to be less accurate and includes fewer impact categories, whilst full LCA tends to be expensive but with higher level of accuracy and a more extensive suite of impact categories. Current practices treat these two approaches separately, resulting in duplication of effort. A more effective approach would be to utilise both streamlined and full LCA as part of a managed transition from concept design to detailed evaluation. This project will develop the capability to assess the confidence in the data that is being used to evaluate concepts and designs as an integrated part of the existing design workflow at Rolls-Royce. This capability will also assist in managing the transition from low confidence data to high confidence data as part of the product development process by highlighting potential hotspots in the life cycle where the effort required to generate firsthand data to replace low confidence data would return an appropriate level of benefit.
- Impact allocation: In certain situations, product level data will not be available or will not return a sufficient benefit to justify the cost of gathering it, whereas factory or company level data will be more widely available and economical. In these situations, we will need to allocate the factory level impacts to products using rational, transparent and traceable apportionment methodologies (such as buy to fly ratios or surface area or part). Part of this project will be to develop these methodologies and the rules/guidance on how to apply them.
- Supplier data gap: 80% of our products are manufactured in the external supply chain. Not all

suppliers will have the resources available to generate the required life cycle impact data to provide complete product evaluation. This project will develop the reporting declaration framework to assist suppliers in generating the required data. The project will also generate generic datasets and fallback links to fill these data gaps where supplier data can't be provided. The scope is expected to cover not just the traditional eco-data associated with supplier products but also the risks associated with restricted substances, critical and conflict minerals content likely to be associated with the products.

- **General enhancements:** Rolls-Royce is experiencing an increase in more defined requirements for product level environmental life cycle data. In response to this and broader business developments, Rolls-Royce has made significant progress in integrating the concepts of sustainability into its business strategy. Satisfying this strategy and the external requirements will necessitate the evaluation of a broader range of impacts than the SAMULET tool currently provides. This project will develop the means to report on these additional impacts, fill data gaps where they exist and integrate assessments into workflows to enable appropriate levels of reporting.

Task 3: Create demonstration software tool: The requirements and methodology will need to be combined into a working tool that provides the required capability to assess product designs at each stage of development across Rolls-Royce. This will likely be a staged process, whereby a single capability requirement is the focus of each stage. Appropriate management of users and data security at each stage will need to be assured as part of demonstrating a capability ready for deployment across the different business areas involved.

Task 4: Test case validation: Using example products, designs and systems, demonstrate the required capability of the tool to assess early design stage concepts through to detailed product designs, integrating with appropriate third party tools in use at Rolls-Royce, managing supplier data and providing fall-back links to enable the assessment of missing data where none currently exists.

Task 5: Finalise tool: Make final adjustment to the tool based on the findings of the test case.

Task 6: Closing report and next steps: Produce closing report, detailing the current tool capability and areas for future development.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title – Description	Type	Due Date
D1	Requirements and specification report: This will be the deliverable from Task 1 . Detailed outline of requirements from stakeholders	Report	T0 + 6 months
D2	Methodology report: This will be the deliverable from Task 2 . A report that details the methodological approach to addressing the identified requirements	Report	T0 + 12 months
D3	Demonstrator tool: This will be the deliverable from Task 3 . This will be the a working tool that incorporates the requirements to date, ready for test case validation	System demonstration	T0 + 36 months
D4	Validation report: This will be the deliverable from Task 4 . This will be a report detailing the findings of the validation test case and the actions to be taken to complete the tool	Report	T0 + 42 months
D5	Finalised tool: This will be the deliverable from Task 5 . Addressing all requirements, specification and feedback from the test case	System demonstration	T0 + 48 months
D6	Closing report. This will be the deliverable from Task 6	Report	T0 + 48 months

Milestones (when appropriate)			
Ref. No.	Title - Description	Type	Due Date
M1	Data: This will be a milestone that is linked to the completion of Task 2 . Completion of major data requirements including schema, handling uncertainty, fall-back links etc...	System demonstration	T0 + 12 months
M2	Demonstrator 1 complete: This will be a milestone that is linked to the completion of Task 3 . Including impact allocation, and closure of supply chain gap	System demonstration	T0 + 18 months
M3	Demonstrator 2 complete: This will be a milestone that is linked to the completion of Task 3 . Including system integration with Rolls-Royce systems	System demonstration	T0 + 30 months
M4	Demonstrator 3 complete: This will be a milestone that is linked to the completion of Task 3 . Including reporting capability	System demonstration	T0 + 36 months
M5	Completion of test case: This will be a milestone that is linked to the completion of Task 4	System demonstration	T0 + 42 months
M6	Completion of finalised tool: This will be a milestone that is linked to the completion of Task 5	System demonstration	T0 + 48 months

4. Special skills, Capabilities, Certification expected from the Applicant(s)

- Skill 1: Ability to balance environmental and materials data to enable trade-offs between function/capability and impact.
- Skill 2: Integration with existing systems at Rolls-Royce to minimise disruptions to workflows (for example Siemens NX, Teamcenter, Granta MI)
- Skill 3: Track record of handling complex materials data.
- Skill 4: Ability to generate fall-back links to generic data (and to provide such generic data) in order to supplement gaps in primary data.
- Skill 5: Knowledge of impact categories such as environmental impact, social impacts, sustainability impacts, regulatory impacts (particularly emerging regulation on restricted substances and material sourcing and supply), geopolitical impacts.
- Skill 6: Ability to manipulate data and to create custom reports for data assessment.
- Skill 7: Demonstrable track record of good data management relating to complex materials information including most particularly appropriate levels of data security, access control and version control etc.
- Skill 8: Knowledge of the standards and practices for conducting Life Cycle Assessments
- Skill 9: Knowledge of and participation in appropriate working groups (particularly ADS, IAEG, ATI).

VII. Jet Noise Reduction Using Predictive Methods

Type of action (RIA or IA)	RIA		
Programme Area	Engines		
Joint Technical Programme (JTP) Ref.	WP5 – VHBR Middle of Market Turbofan Technology – [Ultrafan™]		
Indicative Funding Topic Value (in k€)	400 k€		
Duration of the action (in Months)	36 months	Indicative Start Date⁵²	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-ENG-03-02	Jet Noise Reduction Using Predictive Methods
Short description (3 lines)	
Reducing expensive experimental testing by using computational methods and achieving methods for low noise design, in order to remain in advance of ever tighter emissions targets. This will involve developing reliable Detached Eddy Simulation plus Ffowcs-Williams and Hawkings (DES/FWH) methods aiming to enhance jet noise predictions and consequently improving confidence in numerical methods and best practices. The research will be applied to 3D nozzle designs optimized for specific styles of integration, e.g. various under-wing configurations targeted to lower jet-flap interaction noise emissions.	

⁵² The start date corresponds to actual start date with all legal documents in place.

1. Background

Due to the development of higher bypass ratio, the diameter of aircraft engines increases and other constraints like ground clearance leading to higher close-coupled wing / engine architectures. As a result, the aerodynamic interaction of the jet mixing flow with the wing and its high lift system (flaps) during take-off and landing phases will result in higher noise contribution. This noise source is known as jet installation noise and becomes even more important at future aircraft designs since all other aircraft noise sources will reduce.

The aim of this project is to further develop reliable jet turbulence scales resolving Detached Eddy Simulation plus Ffowcs-Williams and Hawkings (DES/FWH) for installed numerical jet flow noise predictions and consequently improving the confidence in numerical methods and establish or verify best practices. This improved numerical method will allow

- the reduction of expensive experimental testing at model scale and flight tests,
- improving the physical understanding of the noise generation mechanism,
- determining the main parameters and their relationship to the radiated sound field,
- establishing computational methods for low noise design of the exhaust and wing system, and
- much faster design iterations for novel engine / wing configurations

For application and verification of the method experimental data from National and EU-funded programs will be used.

The main tasks can be described as follows:

- Develop reliable DES methods aiming at accurate jet noise prediction (i.e. numeric, meshing and modelling)
- Improve confidence in numerical methods and establish “best practice”
- The methods above will be applied to three-dimensional nozzles optimized for low-jet flap interaction noise tested in national or European Union funded projects.
- The results will be validated using database of national or European Union funded projects.

The work will contribute to increased accuracy and flexibility of jet noise simulations for complex configurations (e.g. jet flap interaction noise). To enable direct exploitation of the results in the industrial context, the development of methods and results should be directly applicable in HYDRA.

2. Scope of work

Develop DES framework to allow numerical simulation of low jet-flap interaction noise designs

Tasks		
Ref. No.	Title – Description	Due Date
1	Development of an appropriate DES/FWH framework for jet noise assessments of close-coupled engine/airframe integration	T0+16 months
2	Simulation of three jet-flap interaction noise configurations (1x baseline w/o flap, 2x jet-flap configurations) and validation with test data	T0+36 months

Task 1

Improvement of RR DES/FWH (near-field aerodynamics with noise plus far-field acoustics) framework in order to enable reliable numerical assessments of jet-wing interaction noise emissions required to better understand close-coupled engine/airframe integration and future low noise nozzle designs (jet noise reduction techniques). It is expected to develop the following capabilities

- DES meshing strategy (on the basis of hybrid structured/unstructured meshes) that achieves an optimal compromise between flexibility to handle complex geometries and quality of results
- Efficient far-field noise integration approach with respect to computational time (e.g. code parallelization), set-up time (e.g. placement of FWH surface) and quality of results
- Procedure to statistically judge DES computations with respect to the initial transition phase length and convergence length (number of time-steps, respectively) in order to get reliable noise results
- Acceleration techniques aiming to shorten the initial transition phase in order to save computation time

Task 2

In order to acoustically judge jet-flap interaction noise configurations three target applications will be investigated. Experimental data are available from national research projects and further completed EU projects.

1. Baseline configuration (reference, w/o flap)
2. Configuration 1 (jet-flap configuration)
3. Configuration 2 (low noise jet-flap configuration)

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
D1	Work plan description on all tasks. (Tasks 1+2)	Document	T0+2
D2	Report on results of development of hybrid meshing strategy (Task 1)	Report	T0+10
D3	Report on results of far field integration method optimization (Task 1)	Report, Code	T0+12
D4	Report on procedure to statistically judge DES computations and initial transition phase acceleration (Task 1)	Report, Code	T0+16
D5	Report on DES simulation of low jet-flap interaction noise configurations and validation (Task 2)	Report, Data	T0+36

Milestones			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
M1	Work plan agreed (D1)	Review	T0+2
M2	Identification and demonstration of appropriate hybrid meshing strategy (D2)	Review	T0+6
M3	Identification and demonstration of optimized far-field integration method (D3+D4)	Review	T0+10
M4	Presentation of DES simulation results of baseline configuration (D5)	Review	T0+16
M5	Presentation of DES simulation results of configuration 1 and 2 (D5)	Review	T0+20
M6	Final report (D1-D5)	Report	T0+36

4. Special skills, Capabilities, Certification expected from the Applicant(s)

This package of work will require expertise in field of DES/FWH for jet noise and jet-flap interaction noise.

The applicant shall:

- substantiate technical knowledge in the domain of proposed tasks
- demonstrate experience in project participation, international cooperation, project and quality management
- show that knowledge is recognized in the scientific community

It would be necessary to have familiarity with the special skills:

- general aerodynamic CFD modelling and method development skills
- Expertise in DES simulation (numeric, meshing and modelling)
- CFD code development skills
- found experience in jet noise /jet-flap-interaction noise simulation with HYDRA
- Aeroacoustics: numerical, analytical, methods, CFD-CAA, far field extrapolation
- Signal processing

The applicant shall ensure that the results are made directly applicable in HYDRA for direct industrial implementation.

VIII. Catalytic control of fuel properties for large VHBR engines

Type of action (RIA or IA)	RIA		
Programme Area	Engine ITD		
Joint Technical Programme (JTP) Ref.	WP 6 – VHBR – Large Turbofan		
Indicative Funding Topic Value (in k€)	350 k€		
Duration of the action (in Months)	36 months	Indicative Date⁵³	Start Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-ENG-03-03	Catalytic control of fuel properties for large VHBR engines
Short description (3 lines)	
The current proposal is aimed at understanding & developing key technologies for increasing the heat sink potential of fuel (de-oxygenation, use of fuel additives, and fuel filtration via catalysts, sorbents and membranes). These key technologies are critical to the successful realisation of oil lubrication and heat management systems for future large geared engines in WP6 of Engine ITD.	

⁵³ The start date corresponds to actual start date with all legal documents in place.

1. Background

As a part of engine projects in Clean Sky 2, the topic manager will lead the design and development of VHBR technologies for VHBR engine demonstrator (WP6 of Engine ITD) for large engine market. One of the key technologies developed to meet the goals of WP6 is an efficient, mass optimised oil lubrication and heat management system.

Future VHBR engines represent a significant challenge for Oil heat management System designs due to significantly increased heat loads, the attendant increase in system oil volumes that come with these heat loads, and a need for more complex control schemes to ensure optimum system performance including off-design conditions.

In order to ensure that the benefits of future VHBR products are fully realised, then these future oil systems are required to be mass optimised to ensure that the increase in system volume does not penalise fuel burn, are more efficient to ensure optimum cycle performance, and are more intelligent to ensure that oil and heat flows are managed across engine the operating range.

The current understanding held by the topic manager is built upon current civil large engine (CLE) best practice and has the following shortcomings with regard to VHBR products:

- 1) System architecture: CLE VHBR products may have their OHM system architectures configured in a variety of schemes; single, dual or separate systems compared to current CLE products that use simple single system architectures.
- 2) Heat rejection capacity: A CLE VHBR will require a significant increase in heat rejection system capacity compared to the current CLE products. Maximum use of the fuel system offers the most efficient method of recovering heat to an engine cycle. If the fuel system is not able to absorb the additional heat produced then the required increase in system capacity will be satisfied by solutions that will erode the performance benefits gained by the VHBR architecture.
- 3) Fuel system limitation: Current CLE engines maximise the available heat sink capacity of the fuel system, in order to absorb additional heat produced by a VHBR engine then fuel system temperatures will have to be increased, leading to reduced life and reliability. Fuel de-oxygenation (de-ox) allows additional heat to be absorbed by the fuel without leading to the deterioration in fluid properties that lead to reduced life and increased system degradation.

The current proposal is expected to deliver higher TRL level understanding of fuel de-oxygenation as a method for extending the heat sink capacity of a VHBR engine heat management system.

The objectives of the current proposal are to:

- I. Research existing technologies for increasing the heat sink potential of fuel by raising maximum allowable fuel temperatures. Candidate technologies should include, but not be limited to fuel de-oxygenation, the use of fuel additives, and fuel filtration via catalysts, sorbents and membranes.
- II. Down-select the optimum technology based on a pre-determined requirements set.
- III. Develop the technology to TRL5 via fundamental study of the underlying principles of operation,

modelling and laboratory based testing as appropriate.

- IV. Undertake studies to determine how best to functionally integrate the selected technology in a VHBR engine heat management system, and quantify it's value in terms of VHBR study engine fuel burn.
- V. Undertake studies to determine how best to physically integrate the selected technology in a VHBR engine heat management system, taking in to account installation and control, cost, weight and reliability constraints and requirements.

2. Scope of work

Tasks		
Ref. No.	Title - Description	Due Date
T1	Management	T0 + 12 months
T2	Technology research	T0 + 12 months
T3	Technology down-selection	T0 + 24 months
T4	Demonstration of oxygen removal	T0 + 36 months

A brief description of the tasks is given below:

Task1: Management

Organisation:

- The partners shall nominate a team dedicated to the project and should inform the consortium programme manager about the name (s) of this key staff

Time schedule and work-package description:

- The partners will work to the agreed time-schedule and work-package description
- Both the time-schedule and the work-package description laid out in this call shall be further detailed and agreed at the beginning of the project.

Progress reporting and reviews:

- Three progress reports (i.e. deliverables) will be written over the duration of the programme
- For all work packages, technical achievements, timescales, potential risks and proposal for risk mitigation will be summarised
- Regular coordination meetings shall be conducted via telecom or webex where appropriate
- The partners shall support reporting and review meetings with reasonable visibility on the activities and an adequate level of information
- The partners shall support quarterly face-to-face review meetings to discuss the progress

Task-2: Technology research

Aviation fuel carried for propulsion offers significant heat sink potential, but in today's engine fuel system architectures, this potential is limited by the maximum allowable fuel temperature. This must be set below the temperature at which fuels start to degrade and form lacquers and deposits that adversely affect the operation of hydro-mechanical units including valves and torque-motors.

It is well known that a significant increase in maximum fuel temperature capability can be achieved by treating fuel to remove most of the dissolved oxygen, (fuel de-oxygenation or 'de-ox'). Technologies exist to achieve this. The same effect can be achieved by introducing fuel additives, although this has operational implications for large commercial aircraft fleets where the volumes of fuel involved are significant. An alternative approach involves elevating fuel temperatures and allowing deposits to form, but then filtering in some way to remove deposits upstream of vulnerable fuel system control units.

This task would involve an extensive literature survey and patent search to gain a complete understanding of fuel treatment technologies and their current TRL, and deliver comprehensive

reporting of these technologies.

Task-3: Technology Down-Selection

Requirements in terms of heat rejection for VHBR engine designs are being defined by the topic owner in parallel programmes of work. This task would involve working with the topic owner to distil the requirements set to a suitable form, and then rigorously evaluating the candidate technologies from Task 2 against requirements to down-select one technology for further research.

Task-4: Demonstration of oxygen removal

Task 4 will depend in detail on the technology down-selected in Task 3. However the following deliverables can be defined irrespective of technology:

- A fundamental understanding of how the technology operates, including limitations and constraints,
- Modelling tools for representing the technology in an integrated thermal management system model, and
- Laboratory demonstration of functionality up to TRL5; this will involve testing with aviation fuel at representative temperatures and pressures.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type	Due Date
D1	<u>Catalytic fuel-de-ox technology research</u> : report presenting findings of research into fundamental physical phenomena governing removal of oxygen from fuel.	Report	T0 + 15 months
D2	<u>Technology down-selection</u> : report summarising selection of catalytic & sorbent materials and definition of design tools created.	Report	T0 + 26 months
D3	<u>Demonstration of oxygen removal</u> : Report presenting modelling tools created and results from rig test demonstrating oxygen removal using catalytic or sorbent process	Report	T0 + 36 months

Milestones (when appropriate)			
Ref. No.	Title – Description	Type	Due Date
M1	<u>Management report</u> : summarise the project management of the programme, including deliverables, level of spend and dissemination	Report	T0 + 12 months
M2	<u>Robust design rules for catalytic or sorbent fuel de-ox process</u> : report summarising the robust design tools created	Report	T0 + 26 months
M3	<u>Demonstration of oxygen removal</u> : report summarising the rig test demonstrating oxygen removal using catalytic or sorbent process	Report	T0 + 36 months

4. Special skills, Capabilities, Certification expected from the Applicant(s)

- Ability to research and understand physical principals of aviation fuel de-oxygenation
- Ability to understand and rate aviation fuel treatment technologies
- Ability to create a laboratory test rig to demonstrate th4e removal of oxygen from fuel at representative flows, pressures and temperatures

IX. Development of coupled short intake / low speed fan methods and experimental validation

Type of action (RIA or IA)	IA		
Programme Area	Engine ITD		
Joint Technical Programme (JTP) Ref.	WP 6 – VHBR – Large turbofan demonstrator		
Indicative Funding Topic Value (in k€)	2800 k€		
Duration of the action (in Months)	24 months	Indicative Start Date⁵⁴	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-ENG-03-04	Development of coupled short intake / low speed fan methods and experimental validation
Short description (3 lines)	
The current proposal is aimed at understanding & developing key technology items critical to the successful realisation of methods to predict & design coupled short intakes and low speed fans so that they can be suitably optimised & competitive for future large geared gas turbine engines. This proposal will evolve the TRL of these key technology items for the large engine market VHBR engine demonstrator in WP6 of Engine ITD.	

⁵⁴ The start date corresponds to actual start date with all legal documents in place.

1. **Background**

As a part of engine ITD in Clean Sky 2, the topic manager will lead the design and development of VHBR technologies for VHBR engine demonstrator (WP6 of Engine ITD) for large engine market. One of the key technologies to be developed to meet the goals of WP6 is a low speed, low pressure ratio fan.

Future VHBR engines represent a significant challenge for aerodynamic designs of fans & nacelle's as there is a growing drive to reduce drag and weight, optimise the thrust, reduce specific fuel consumption and reduce the impact and occurrence of aerodynamically induced phenomena such as flutter.

In order to ensure that the benefits of future VHBR products are fully realised, then these potential future engine architectures and geometries need to be investigated to ensure that sufficient understanding exists to create robust, competitive and light weight LP systems.

The current proposal is expected to deliver data to support Rolls-Royce developing their various analytical methods to a TRL6 level understanding.

The objective of the current proposal is to develop capability and test a scaled representative fan system. Key factors include:

- Driving a fan of approximately 46" diameter at tip speeds of up to 1500 feet/second and maintain accuracies of 0.05% of controlled values.
- Test in wind tunnel conditions with running cross wind angles varying from 0° to 135°.
- Cross wind speeds up to 50 knots.
- Represent a ground plane for certain testing.
- Instrumentation capability including flow velocities, microphones, pressures, tip timing system & strain gauges
- Interface for Rolls-Royce supplied hardware and instruments.

2. Scope of work

Tasks		
Ref. No.	Title – Description	Due Date
T1	Management	T0 + 24 months
T2	Develop experimental capability & interfaces	T0 + 12 months
T3	Install & prepare test vehicle	T2 + 4 months
T4	Test of provided hardware	T3 + 4 months
T5	Reporting	T4 + 4 months

A brief description of the tasks is given below:

Task1: Management

Organisation:

- The partners shall nominate a team dedicated to the project and should inform the consortium programme manager about the name(s) of this key staff

Time schedule and work-package description:

- The partners will work to the agreed time-schedule and work-package description
- Both the time-schedule and the work-package description laid out in this call shall be further detailed and agreed at the beginning of the project.

Progress reporting and reviews:

- Progress reports (i.e. deliverables) will be written over the duration of the programme
- For all work packages, technical achievements, timescales, potential risks and proposal for risk mitigation will be summarized.
- Regular coordination meetings shall be conducted where appropriate to an agreed format between the parties.
- The partners shall support reporting and review meetings with reasonable visibility on the activities and an adequate level of information. This includes supporting the Rolls-Royce design process for the test vehicle to be tested on the facility, specifically in the determination and resolution of interfaces between the test facility and test article.

Task-2: Develop Experimental Capability & Interfaces

Develop a wind tunnel facility such that it can meet the Rolls-Royce test requirements. These are, but are not limited to:

- Driving a fan of approximately 46" diameter at tip speeds of up to 1500 feet/second and maintain accuracies of 0.05% of controlled values.
- Test in wind tunnel conditions with running cross wind angles varying from 0° to 135°.
- Cross wind speeds up to 50 knots.

- Represent a ground plane for certain testing.
- Instrumentation capability including flow velocities, microphones, pressures, tip timing system & strain gauges
- Interface for Rolls-Royce supplied hardware and instruments.

Task-3: Install & Prepare Test Vehicle

Rolls-Royce will provide a test vehicle in an agreed condition of assembly.

The partner will be expected to:

- Perform all specified actions to complete assembly (if required). Rolls-Royce hardware will be delivered with sufficient drawings and scheme paperwork to accomplish this. This may include activity such as rotor balance and inspections. In this event, Rolls-Royce may require them to be performed to defined Rolls-Royce test specifications.
- Connect instrumentation delivered as part of the test vehicle.
- Apply any additional instrumentation that the partner deems necessary for integrity & safety.
- Demonstrate conformance of work performed in line with Rolls-Royce and relevant industry standards & processes.

Task-4: Test of Provided Hardware

Perform all the testing agreed between Rolls-Royce and the partner.

Detailed records must be kept of all actions performed during test and an agreed set of data must be retained and provided to Rolls-Royce to enable exploitation.

Task-5: Reporting

A detailed report/s must be produced at the end of the project detailing the full suite of work performed.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type	Due Date
D1	<i>Produce a detailed report outlining full content of the project</i>	Report	T0 + 24 months
D2	<i>Demonstrate that the facility design meets key agreed interfaces.</i>	Report	T0 + 6 months
D3	<i>Demonstrate that the facility possesses key capabilities required to run full Rolls-Royce test schedule. Demonstrate this at a Rolls-Royce Assembly Readiness review.</i>	Report	T0 + 12 months
D4	<i>Demonstrate that the test vehicle is fully and correctly installed and that the facility conforms to the necessary standards to allow testing. Demonstrate this at a Rolls-Royce Test Readiness Review.</i>	Report	T0 + 16 months
D5	Complete the agreed Rolls-Royce test schedule within key agreed criteria.	Rig	T0 + 20 months

Milestones (when appropriate)			
Ref. No.	Title – Description	Type	Due Date
M1	Assembly Readiness Report	Report	T0 + 12
M2	Test Readiness Report	Report	T0 + 16
M3	Test report	Report	T0 +24

4. Special skills, Capabilities, Certification expected from the Applicant(s)

- It is expected that the partner has significant experience of testing aerospace assemblies in a wind tunnel facility.
- It is expected that the partner has experience applying cross-wind to aerospace assemblies.
- It is expected that the supplier has experience producing/supplying detailed models and drawings of their facilities and these standards are at a minimum standard to conform with the Rolls-Royce rig design process standards. This is to allow design in context and reliable interfaces.
- It is expected that the partner has the capability to make or procure the high tolerance components required to interface with a Rolls-Royce, aerospace standard test vehicle.
- It is expected that the partner can display compliance with all the quality standards and procedures that Rolls-Royce apply to their supply chain. This includes rigorous conformity inspection of key components, calibration of instrumentation etc.

X. Powerplant Shaft Dynamic and associated damping system

Type of action (RIA or IA)	IA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP7.1 Light weight and efficient Jet-fuel reciprocating engine		
Indicative Funding Topic Value (in k€)	350 k€		
Duration of the action (in Months)	18 months	Indicative Start Date⁵⁵	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-ENG-04-05	Powerplant Shaft Dynamic and associated damping system
Short description (3 lines)	
Design and test of a propeller dedicated for direct drive jet-fuel reciprocating engine. The propeller stress and the powerplant dynamic behaviour will be analysed and may additionally lead to include damping devices.	

⁵⁵ The start date corresponds to actual start date with all legal documents in place.

1. Background

The “compression ignition” engines burning the aeronautical kerosene/Jet fuels, otherwise called “diesel” engines, can reduce fuel burn by 50% to 65% compared to a small turbine engine, and by 30% to 50% compared with an avgas engine. These points bring both an environmental benefit and a drastic reduction of operating costs. Replacement of an Avgas piston engine by a diesel engine brings a high cumulative benefit of fuel burn and fuel price reduction.

Jet fuels are also worldwide available, have a low flammability and are lead free.

On the first generation of diesel engines, the weight penalties were, for a medium range mission, more or less compensated by the fuel weight savings, but with the new high power density diesel engines, the global weight balance can be favourable to diesel versus avgas engines, even for short flight legs. Thus, it provides an additional benefit of payload for a medium range mission.

A similar conclusion is obtained when new diesel engines and turbines are compared.

There are also additional benefits for the diesel engines as:

- The lower speed of rotation allowing important noise reduction, both inside (in the cabin) for passengers and pilots comfort, and outside for the community. This last point may allow the survival of airfields near cities and by consequence the development of the small aviation transportation market.
- Reduction of the number of levers (no mixture) for a simpler control by the pilot,
- Reduction of inspection and maintenance (no magnetos, no sparks igniters ...).

Thus, the use of piston engines burning the affordable and worldwide available Kerosene fuel is a logical step to overcome these drawbacks. Airframers producing small airplanes create strong pressure to engine manufacturers to get their compression ignition power units more mature and certified with high performance.

2. Scope of work

Along with the development of high power density compression ignition engines, the powerplant integration faces new challenges as the shaft dynamic behavior with its interaction with the propeller. Indeed, due to a high compression ratio to ignite the air-fuel mixture, a diesel engine generates high torque pulses associated with a relative low speed of rotation compared with regular engines.



Nota: here below, many options are mentioned. The “main” ones are mandatory. The other ones are wishes.

Scope of work :

1. **Main :** Design, manufacturing and test of a constant speed propeller for a 4 cylinder diesel cycle direct drive engine (hub, blades, bearings, cone, governor, counterweights etc...),
2. Option : Engine dynamic damping and tuning (for SR460) in accordance with the propeller (option of damper integrated in the propeller itself – can be tested on SR305),

Goals & Criteria :

- **Main**
 - Capable to sustain an increase baseline engine power by +20% (consistent with WP7.1.1 – ie up to about 280 hp) with low propeller maintenance (propeller TBO & intervals between inspections consistent with the engine ones and GA market),
 - Diameter < 2m, weight < 30 kg, max efficiency over 85% at 2200 rpm
 - Clockwise (aft looking forward),
 - Technology capable to be certified.
- **Secondary**
 - No negative impact on costs: affordable technology consistent with the GA market.
 - No negative impact on performance (thrust, noise, FOD & erosion resistance),
 - Capability to be inspected and repaired on the field after usual FOD (by grit) and erosion when used on laterite runways,
 - Technology capable to be implemented on feather and reverse versions,

Propellers configurations :

1. **Main :** Composite propeller
2. **Option:** Metallic propeller (only for SR460)
(This alternative may be not studied, if the composit propeller cost is really demonstrate affordable and comparable with a metallic propeller and capable to be repaired in the field).

Damping configuration

1. **Main :** None
2. SR305 option : if integrated in the propeller
3. SR460 option : tuning studies and tests

Field of test

1. **Main : Dynamic studies**
 - Engine and propeller dynamic measurements for the different configurations in order to analyse, design and pass the criteria,
 - Power variation from idle to baseline + 20%
 - Engine RPM :
 - Start and stop behavior (0 – 200 rpm),
 - Idle behavior (500 – 1000 rpm),
 - Nominal :
 - **Main:** 2200 (reference) and 2400 rpm
 - **Options :** 2000 and 1800 rpm
 - Transient phase behavior.
2. **Option : Aerodynamic performance**
 - Thrust measurement at zero speed,
 - Ideally : Efficiency and thrust measurement in wind tunnel for different airspeed.
 Flight test may be performed in order to correlate with wind tunnel tests and measure installation effect. In such a case, a noise measurement should be performed.

Conclusion

The role of the partner(s) is :

- to complete the specification,
- to develop some solutions,
- to elaborate a propeller system prototypes,
- to prepare tests, instrumentation and performed analysis,
- to demonstrate goals and criteria achievement.

Several partners can join together to answer the different areas : propeller, test cell, damping systems etc.

Rig tests and wind tunnel if any, will be performed by the partner(s).

The engine tests will be performed with an engine(s) provided by the leader, in a dedicated test cell to be proposed by the partner(s), to be agreed with the leader in order to make easier the engine installation.

Tasks		
Ref. No.	Title - Description	Due Date
Task 1	Elaboration of specifications and development plan - requirements analysis - pre-selection of the state of the art technologies, - Elaboration of the development plan and detailed schedule.	T0 + 3 months
Task 2	Development of solutions - design of the propeller components, calculations, simulations - design of the damper devices - test plan and instrumentation preparation	T0 + 6 months
Task 3	Manufacturing a modified propeller system - at least one sample, and may be some variants according to the specifications	T0 + 12 months
Task 3	Engine Test to demonstrate the propeller achievements - as describe above	T0 + 18 months

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type	Due Date
D0	Design Specifications & Development plan	S	T0 + 3 months
D1	Design review	D	T0 + 6 months
D2	Prototype part delivery	P	T0 + 12 months
D3	Test results	R	T0 + 18 months

Design Specifications & Development plan

Milestones (when appropriate)			
Ref. No.	Title - Description	Type	Due Date
D1 M1	Dynamic results on SR305 demonstrator @ 260 hp and 2200 rpm	R	T0 +15 Months

D
T0 + 6 months

D2

4. Special skills, Capabilities, Certification expected from the Applicant(s)

P
T0 + 12 months

The partner should have a strong experience in propeller manufacturing.

Test results
Experience in propeller design and testing,

- R
- Experience in dynamic calculation and damper solutions, T0 + 18 months
 - Experience in production with aeronautical standard of quality,
 - Experience in design and prototype manufacturing,

Milestones (when appropriate)

English or French language is mandatory.

Ref. No.

Title - Description

Type

Due Date

M1

Dynamic results on SR305 demonstrator @ 260 hp and 2200 rpm

R

T0 +15 Months

5. Special skills, Capabilities, Certification expected from the Applicant(s)

The partner should have a strong experience in propeller manufacturing.

- Experience in propeller design and testing
- Experience in dynamic calculation and damper solutions,

1.6. Clean Sky 2 – Systems ITD

I. Very high brightness & compact full color display for next generation eyes-out cockpit products

Type of action (RIA or IA)	RIA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP Level 1 – WP1: Extended Cockpit		
Indicative Funding Topic Value (in k€)	3800 k€		
Duration of the action (in Months)	36 months	Indicative Start Date ⁵⁶	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-SYS-01-01	Very high brightness & compact full color display for next generation eyes-out cockpit products.
Short description (3 lines)	
The objective is to develop a new generation of emissive micro-displays with full color, very high brightness, low power and good form factor capabilities that will enable the design of ground breaking compact see-through systems for next generation Avionics applications.	

⁵⁶ The start date corresponds to actual start date with all legal documents in place.

1. Background

Ground breaking solutions in future generation of cockpit such as windshield projection or advanced head worn solutions require a very large amount of optical power to remain usable in avionic sunlight environment. Moreover these micro-displays components - as well as the optical engine solution associated - have to present a compact form factor and a very good power optical efficiency to be easily integrated in cockpit solutions.

Each existing micro-displays solution suffers from either different issue when considered for the application:

- Color transmissive LCDs are limited by their very low light transmission. They are power consuming and have difficulties to achieve a very high brightness with full color capability in single display solutions. Moreover Backlighting module appears to be bulky due to the consequent volume of the thermal management system.
- System based on reflective LCOS micro-displays are bulky and heavy because they need a Polarising Beam Splitter (glass cube at display size or a little bigger), and are also difficult to use with high field of view and large pupil system.
- Micro mirrors and MEMS are also bulky to integrate in compact systems and not compatible with large pupil system. They might also be limited in resolution.

To save on volume, cost and power consumption and to facilitate the integration in the optical engine, it appears that micro-displays with emitting pixel elements are the best solutions.

OLED micro-displays are based on emitting pixel elements. They demonstrated very good optical properties and are, for the time being, the only component easy to integrate in a compact optical engines. But unfortunately OLED phosphorescent or luminescent materials cannot reach the expected level of brightness with a sufficient lifetime even for monochrome applications. For color displays where the surface allocated to each color is $1/3^{\text{rd}}$ of the display surface, the problem is even more severe. Brightness at each single diode is multiplied by 3 thus reducing the lifetime by a factor of at least 6 which is not compatible with the application.

Some innovative solutions such as emissive micro-displays based on arrays of color LEDs structured on sapphire wafers and coupled to a silicon backplane active matrix should be able to provide more than $1.000.000\text{cd/m}^2$ at a compatible size and pitch with almost no limitation on life time (inherited from the maturity of the solid state GaN LED technology). Such a solution will allow the design of very compact solutions while keeping a significant margin in brightness for future Avionics Eyes Out Applications.

When this development reaches its objectives, these micro-displays technology will also be used in large public markets for both automotive Head Up Displays and also, more widely, for consumer projectors products, which should extend significantly in the next few years.

2. Scope of work

The final objective of this topic is to deliver monochrome and full color micro-display prototypes for their integration in an avionic windshield projection demonstrator.

Although the main requirements for these single colour and full colour prototypes are listed below:

- Maximum brightness : at least of 1.000.000 cd/m² and possibly 10.000.000 cd/m²
- Targeted Resolution : 1920x1200 pixels (WUXGA)
- Die Size ~ 1'' diagonal (inducing a Pixel pitch ~ 8-10µm)
- Spectral BandWidth < 50 nm
- Selected half angle of emission ~ 30°
- Video Frequency Refresh : at least 50-60Hz
- Intra-scene Contrast > 500:1
- Targeted micro-display power consumption < 0,1 W per output lumen
- Reduce set of defective pixels and no visual defects altering the image displayed.
- Angular and spatial uniformity of micro-display brightness and spectral bandwidth.
- Component Life-time up to several thousands of hours.

It has to be understood that 1million Cd/m² for colour and 10 million cd/m² for single colour displays are the ultimate requirements of the project. They are far beyond the possibilities of the existing emissive technologies today. A first target of 1million cd/m² for single colour displays and 100 kcd/m² on full colour displays would already represent a significant breakthrough enabling the application in the cockpits.

The work breakdown and deliverables proposed here below to achieve this goal may be rearranged by the partners to facilitate their workflow.

Tasks		
Ref. No.	Title – Description	Due Date
WP1	Development of monochromatic emissive materials and optimisation of their optical efficiency.	M18 green M24 (red)
WP2	Development of array structuration process or deposition process.	M24
WP3	Design of color Active Matric backplane compatible with monochromatic applications.	M18
WP4	Research of solutions for high brightness full color applications with optimized optical efficiency.	M26
WP5	Design and manufacture of emissive monochrome green micro-display prototypes	M28
WP6	Design and manufacture of emissive full color micro-display prototypes	M32
WP7	Development of micro-display mother-Board and complete characterisation of developed components	M36

2.1. WP1 : Development of monochromatic emissive materials and optimisation of their optical efficiency.

The objectives of this work package are to deliver solutions for monochromatic emissive stacks or components (Green, Blue and Red) in specified wavelength ranges. They have to generate at least more than 1 million of lux while keeping a sufficient life time for avionics applications. The spatial and angular brightness uniformity, bandwidth selectivity and bandwidth angular and spatial uniformity of these materials will also be tightly monitored in this WP. Partners should develop and manufacture either raw materials or sources for electro-optical components to be used in WP2 or WP4 to build the arrays of electro-optical elements both single color and full color. It is also the purpose of this WP to characterize the performance of each solution.

This WP should benefit from the experience of Advanced Research Institute with a strong background on emissive technologies and materials and on their own industrial experience to offer solutions that can be produced on industrial equipment.

Several iterations of materials might be needed before the delivery of full color electro-optical components, based on proposal of WP4 – compatible with pixel array structuration solutions in WP2 - and bonded to silicon in WP5 to achieve the expected performances of the micro-displays.

2.2. WP2 : Development of array structuration process or deposition process.

The objective of this work package is to develop the process (material array structuration or deposition) to produce an organized array of pixels with the high efficiency emissive materials of WP1 at the targeted pitch and brightness. This work will be done for each monochromatic emissive material (Green, Blue and Red) designed in WP1. Once again the spatial and angular brightness uniformity, bandwidth selectivity and bandwidth angular and spatial uniformity of these materials will be monitored in this WP but also the cross-talk between pixels in order to ensure high contrast capability of the matrix. The capacity to design pixels within a targeted angular selectivity will also be a key driver to ensure the efficiency of the complete optical engine.

It is also possible that color definition is only achieved at this stage based on materials of WP1 and architectures of WP4.

The WP will pay a special attention to the compatibility of the solutions with available industrial equipments. The target there is to demonstrate a solution that can be manufactured at a reasonable cost with the expected performances and an acceptable number of defect per cm² (<1ppm).

2.3. WP3 : Design of a color Active Matrix backplane compatible with monochromatic applications.

The objective of this work package is to design the specific active matrix backplane at the specified pitch and targeted resolution (cf. WP6 & 7) to drive independently each pixel of the array of emissive optical elements supplied by WP2 at a given video frequency to deliver the requested number of grey levels on the pictures.

There are two kinds of requirements for the silicon. First, the CMOS chip specification should be able to provide voltage and current to each pixel cell to display pictures of the highest quality to the user. This task might include (non exhaustive list) designing a high speed digital interface to the system, designing digital to analog converters to supply analogic information to the pixel elements, to compensate for non uniformity on the characteristics of electro-optical elements in the electrical design, to compensate for the drift of the optical performance of the pixels in operation or in temperature and to offer a high range of dimming. The design has to take into account the requirements of the system designer for the video interface, the environmental conditions and the optical performance of the system as well as the electro-optical characteristics of the optical elements provided by WP1 and WP2

Second, the integrated circuit has to be manufactured in a silicon foundry that is able to provide process adjustment of final pixel layers on the latest high voltage CMOS technology to enhance the performance of the electro -optical solutions and to enable a close electrical contact between the array of pixel drivers and the array of emissive pixel elements.

The active matrix should be compatible with different color applications at the same resolution.

It is believed that since the integrated circuit is coming from an operating silicon foundry, both design and processes can be manufactured in larger volumes.

It could be a good practise to test the solutions for the design of the integrated circuit on smaller volumes of products.

Note that partners may propose the design of a first “small backplane” prototype with a lower resolution in order to ensure to obtain all the characteristics of the final prototype.

2.4. WP4 : Research of solutions for high brightness full color applications with optimized optical efficiency.

The objective of this work package is to search for different solutions of stacks and / or pixel array organisation with their associated pixel array generation process in WP1 in order to provide 3 different colors at the pixel level at very high brightness (more than 1 million lux each) on the same active matrix. All the solutions proposed will then be sorted out and only the most promising ones - compatible with the targeted pitch (and other micro-displays specification from WP6) - will be prototyped and evaluated in order to select the solution for implementation of a full color micro-display in WP7. This work package is certainly the most advanced part of the workprogram since up to now very high brightness color solutions for emissive micro pixels do not exist.

2.5. WP5 : Design and manufacture of emissive monochrome green micro-display prototypes.

The objectives of this work package are - thanks to the work performed through WP1 to WP3 - to design, realise and characterise several prototypes of full functional monochrome green micro-displays compliant with the key specifications listed below:

- Maximum Brightness : at least of 1.000.000 cd/m² in green and possibly 10.000.000 cd/m²
- Targeted Resolution : 1920x1200 pixels (WUXGA)
- Spectral BandWidth < 50 nm

- Die Size $\sim 1''$ diagonal (inducing a Pixel pitch $\sim 8\text{-}10\mu\text{m}$)
- Selected half angle of emission $\sim 30^\circ$
- Video Frequency Refresh : at least 50-60Hz
- Intra-scene Contrast $> 500:1$
- Targeted micro-display power consumption $< 0,1$ W per output lumen
- At least 255 levels of gray and possibly 1023 levels for gamma correction.
- Reduce set of defective pixels and no visual defects altering the image displayed.
- Angular and spatial uniformity of micro-display brightness and spectral bandwidth.
- Component Life-time up to several thousands of hours.

Partners should pay a special attention to the integration of the electro-optical solution on the active matrix which requires a very high density of electrical contacts with a extremely good yield (defect rate $< 1\text{ppm}$) compatible with the avionics environment.

The tasks performed in this work package must also include the bonding of the component to a specifically designed and manufactured daughter board and all the mechanical, optical and environmental packaging (including thermal management) required for a proper use of these prototypes at the system level.

2.6. WP6 : Design and manufacture of emissive full color micro-display prototype.

The objectives of this work package are - thanks to the work performed through WP1 to WP3 and using the full color matrix array solution selected in WP4 - to design, realise and characterize several prototypes of full functional color micro-displays compliant to the key specifications listed in WP5 expect those listed below:

- Maximum Brightness : at least of 100.000 cd/m^2 in white and possibly $1.000.000\text{ cd/m}^2$
- 255×3 levels for each color.

An intermediate step of a bicolor micro-display prototype using a couple of specific very close wavelengths should also been realized to implement a specific avionics functionality.

The concern on the integration of the electro-optical solution on the active matrix is even more severe on a full color array.

The tasks performed in this work package must also include the bonding of the component to a specifically designed and manufactured daughter board and all the mechanical, optical and environmental packaging (including thermal management) required for a proper use of these prototypes at the system level.

2.7. WP7 : Development of micro-display MotherBoard and complete characterisation of developed components.

The objectives of this work package are first of all to design and manufacture an “evaluation board” that will be used to perform the integration of the micro-display component video capability. This evaluation board should allow to plug the micro-display daughter board using (or not) a flex.



The other goal of this work package is, after the basic device characterization performed on WP5 & WP6, to conduct here - at a system level point of view - a complete set of measurements of electrical, optical (static and dynamic) and environmental performances what will assess the component compliance with all the requirements listed by the Systems ITD at the beginning of the project.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title – Description	Type	Due Date
D1.1	First macro-pixel structure of green emissive material with characterization report		M12
D1.2	Optimized single macro-pixel structure of green emissive material with characterization report.		M18
D1.3	Optimized single macro-pixel structure of red emissive material with characterization report.		M24
D1.4	Optimized single macro-pixel structure of blue emissive material with characterization report.		M24
D2.1	Report on optimized matrix array generation process using WP1 materials and key requirements to the development of the active matrix		M18
D2.2	Prototype of passive monochrome green array of pixels with characterisation report.		M24
D3.1	Active Matrix Backplane requirements report		M5
D3.2	WUXGA Active Matrix Backplane chip design report (ready to manufacture)		M17
D4.1	Report on the comparison of technologies for the high brightness full color array with optimized optical efficiency		M26
D4.2	Prototype of passive full color array of pixels with characterisation report.		M30
D5.1	WUXGA Active matrix backplane manufactured with wafer-level test report		M22
D5.2	Full functional WUGXA monochrome green device packaged on its daughter board		M28
D6.1	Full functional WUGXA dichromic green device packaged on its daughter board		M30
D6.2	Full functional WUGXA full color device packaged on its daughter board		M36
D7.1	Full functional driving motherboards for the color and monochrome WUXGA displays prototypes		M24
D7.2	Complete Report on green WUXGA monochrome display performance.		M32
D7.3	Complete Report on green WUXGA monochrome display performance.		M36

Milestones (when appropriate)			
Ref. No.	Title – Description	Type	Due Date

4. Special skills, Capabilities, Certification expected from the Applicant(s)

Skill 1: Raw material and processes

Whether the solution for very high brightness micropixels, there will imply a strong request for innovation on the raw materials and processes for the development of the most efficient devices. The partners should demonstrate that they have the knowhow and the background to push display or lighting materials and processes to their limits either in size or in power efficiency and quality in order to achieve expected performances at each single pixels with a good uniformity. They also have to demonstrate that they can rely on Advanced Research Institutes that are able to monitor the theoretical operation of the materials involved, as well as the modelling of the improvement or the innovation in progress. The advanced research institutes that are active in the field of display materials and components are thus welcome in the research program.

Skill 2: Optical effect for high brightness pixel array

The project is looking for an electro-optical solution for very high brightness micro pixels. This very specific skill is the mastering of the technology (design and process) to get a very high luminous output out of high quantity of micro-elements located next to each others. The partners should demonstrate the control of an optical technology that can provide the expected amount of light on the projected pixel size which is also compatible with the integration into an array of more than 2 million elements without any problems such as optical or electrical crosstalk, uneven power or brightness distribution, a bandwidth down to the pixel level, compatible with the thermal management capability of the system but which is also able to achieve colors, a low defect rate (0.1ppm), a good contrast, a fast response time and wide optical dynamic range in the operating temperature range and in all avionics operating conditions.

What is expected is a very good understanding of the limitations of the different existing technologies in order to push their performances into new limits. It has to be supported by new ideas, proofs of concepts and validated intellectual property rights. The partner will use its strong relations with raw materials suppliers providing the elements according to the requirements of the application and with advanced research institutes on the other end, providing the theoretical understanding, the modelling and low level prototyping capability and to support the innovation process. These advance research institutes are also welcome in the program.

What is also expected is the access to high technology solutions to build very advanced optical components such as clean rooms, lithography equipments, coating and etching machines able to provide a very high density of components. The partner in charge of the optical effect should demonstrate its industrial capability in providing the different samples of high brightness electro-optical arrays which will be needed along the project development but also in demonstrating his business plan and his strategy for the future growth of the technology.

Skill 3: Active matrix pixel array on silicon design and manufacturing

It is highly probable that the microdisplay will request the design of a very specific integrated circuit such as an array of isolated pixel elements which is called an active matrix display. Whatever the

technology, there will be requirements at the pixel level on electrical design and on pixel materials to interface electrically, optically, chemically and mechanically with the electro-optical element or effect. Two partners or two competences are needed there: the first is the capability to understand the electrical operation of the optical element and to design the circuit able to drive it in all operating conditions to provide the best picture quality, the second deals more with material implementation on chip to achieve the most efficient integration of the electro-optical element in order to achieve 100% yield and optimal optical efficiency.

Each pixel of the active matrix is connected to at least a row and a column that are driven by integrated circuits that are connected to the video input. Electrical design of the interface between the outer world and the rows and the columns is already strongly related to system design and to microdisplay performance. Chip operation should be perfect in all operating conditions in the aircraft: day or night, cold or hot, Radio On or Off...

The first competence is a silicon design house with a good knowledge on pixel arrays while the second skill is a silicon foundry with process development and advanced design rules capability since the dot clock of the chip will be close to 200MHz with 8bits digital to analog conversion on chip.

Skill 4: Integration of optical and electrical technologies

The integration of the electro-optical technology on the silicon chip will request specific equipments or processes compatible with both types of components: the silicon chip and the array of electro-optical elements. It can be either a vacuum deposition chamber to coat each layer of the optical element on the pixel electrodes on silicon or a bonding machine to connect the optical part of the pixels to each electrical circuit on the silicon chip or another machine specific to the optical effect. The integration technology should offer a 100% yield without creating losses in the optical or electrical path and strong enough to be compatible with the environmental conditions of the aerospace industry. Although technologies for the optical effect or silicon technologies are well known, integration technology is very unique and dedicated to the application. It is definitely one of the critical step of the project.

The partner should also have the capability to implement the most appropriate packaging technology for the device under development to manage both electrical, optical and thermal operation of the micro-display in the system.

All means used in the project to manufacture the prototypes should be available for production in an industrial environment or should have a plan covering their development for an industrial application

Skill 5: Assessment of microdisplay optical performance

Capacity and means necessary for a classical optical testing of the microdisplays.

II. Advanced Landing Gear Sensing & Monitoring – ALGeSMo

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP4 – Landing Gear Systems		
Indicative Funding Topic Value (in k€)	2400 k€		
Duration of the action (in Months)	36 months	Start Date ⁵⁷	Q2-2016

Identification	Title
JTI-CS2-2015-CFP02-SYS-02-09	ALGeSMo
Short description (3 lines)	
Advanced Landing Gear Sensing & Monitoring – ALGeSMo – is a system that will measure load at the landing gear to provide loads data for use on the aircraft systems for integration with aircraft health monitoring, hard landing detection, flight management and flight controls. The work will consist of developing and flight testing landing gear loads measurement technology towards further functional integration in large aircraft avionics systems.	

⁵⁷ The start date corresponds to actual start date with all legal documents in place.

1. **Background**

Advanced Landing Gear Sensing & Monitoring – ALGeSMo.

Airbus aircraft do not currently incorporate landing gear load sensors into their production aircraft; it is currently the responsibility of the pilot to declare any landing overload situation.

Furthermore, it is the responsibility of the ground support crew and flight crew to compute and set the on-ground weight and CG position in the flight management computer.

The introduction of a landing gear load measurement system would provide the following benefits:

- Accurate and rapid classification of hard landing and overload events
- Automated and accurate weight on wheels and CG position measurement
- Automated take-off settings for HTP trim and Thrust (tail-strike protection)
- Optimised ground trajectory and load control (co-ordinated turns using steering and braking)
- Sensitive detection of air-ground transition
- Landing Gear life and structural health assessment
- Landing Gear health monitoring in support of Total Care Maintenance packages

2. Scope of work

The ALGeSMo project is concerned with the integration of sensors into large passenger aircraft landing gear to provide robust, accurate, reliable load measurement and the potential for health monitoring capability. The sensors measure loads using a new strain gauge technology which is based on optical Fibre Bragg Grating sensors. This technology is essential as it enables measurement of the very high strains experienced during a heavy landing and is robust to the harsh environment. The system therefore relies on cutting edge opto-electrical hardware to drive the sensors. Currently there is no certified avionics unit capable of interfacing with optical strain gauges, this project aims to develop the first. Optical sensor technology extends beyond just strain measurement, making such an optronic device a key missing component in future aircraft system development.

The system will also measure the compression of each landing gear shock absorber by measuring the relative angle between the landing gear main fitting and the torque link by use of a rotary sensor.

The scope of work encompasses a complete system development; system architecture definition, equipment specification, design, manufacture, test and integration. The aim of the project is to take a fully integrated system through to flight test on a single aisle aircraft and demonstrate the system to TRL 6.

The activities expected from the applicant will be part of the Clean Sky 2 JTP Work Package 4 “Landing Gear Systems”, which will lead into a dedicated sub Work Package led by Airbus, WP 4.4.

The corresponding breakdown of tasks is split into four sub work-packages as described in the table below:

Tasks		
Ref. No.	Title – Description	Due Date
WP01	Project Management: Internal management and External reporting	Monthly intervals
WP02	Manufacture & Assembly: Sensors; RVDT; FOPU; Connectors & Cables; Software; Integration; Tooling	2016-2017
WP03	Testing: Specifications, Requirements & Planning; Test Rig Specifications; Test Rig Design; Test Rig Construction/Configuration; Functional & Performance Testing; System Testing	2016-2018
WP04	Flight Testing: Flight Test Specifications & Requirements; System Build & Integration; Flight Tests	2019

WP01: Creation and update of project plan, Gantt schedule, statements of work, risk/opportunities register and reports demonstrating progress as appropriate.

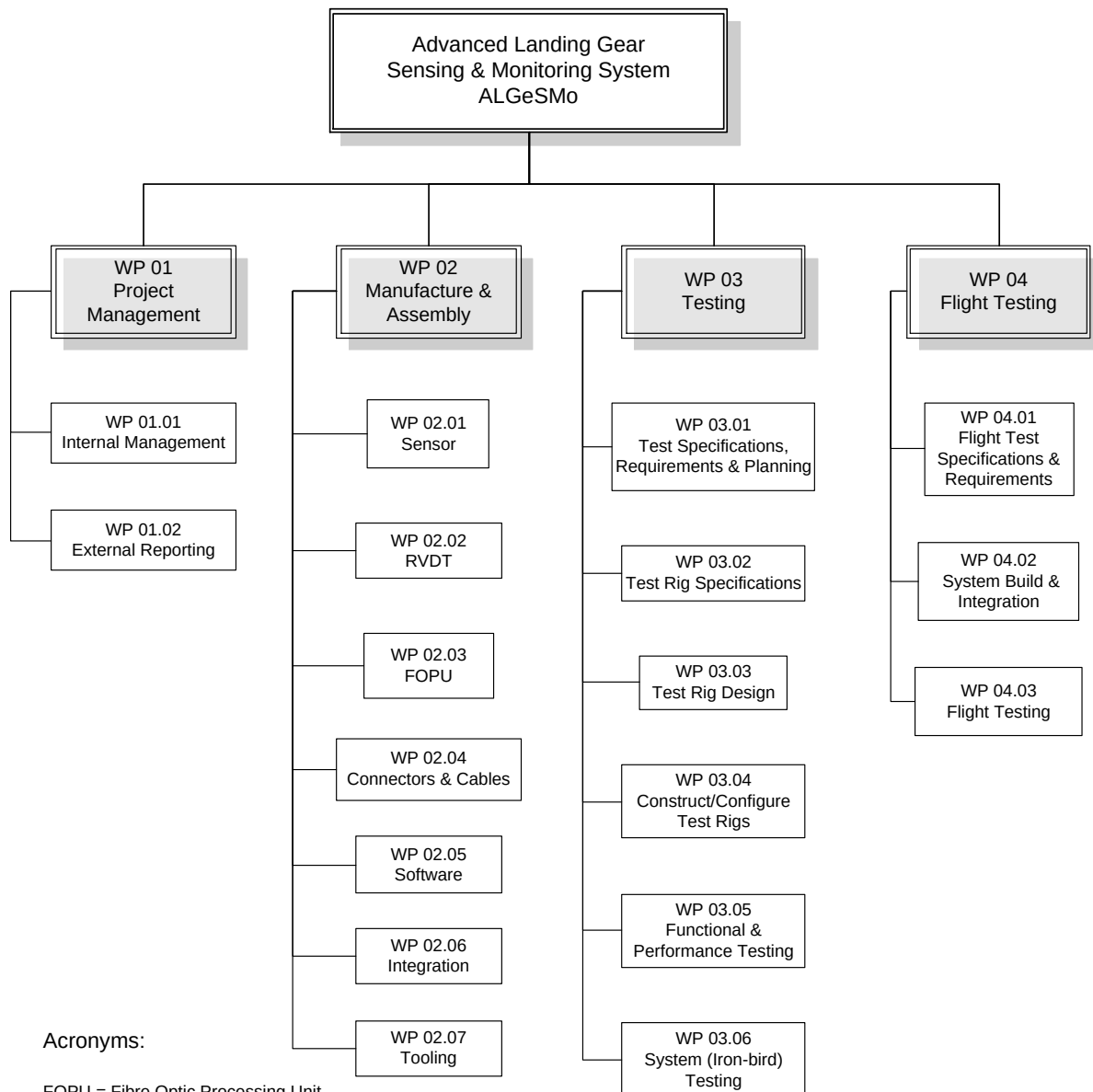
WP02: Manufacture and delivery of sensors, processing units, connectors and cables; software code; performing integration activities; provision of tooling.

WP03: Provision of test specifications; test parameter requirements; test plans; test rigs including

design; integration of the systems components to be tested; functional and performance testing; publication of test reports.

WP04: Provision of flight test specifications and requirements; configuration and build/assemble the flight test system; conduct on-aircraft testing.

The WBS for ALGeSMo is shown below:



Acronyms:

FOPU = Fibre Optic Processing Unit

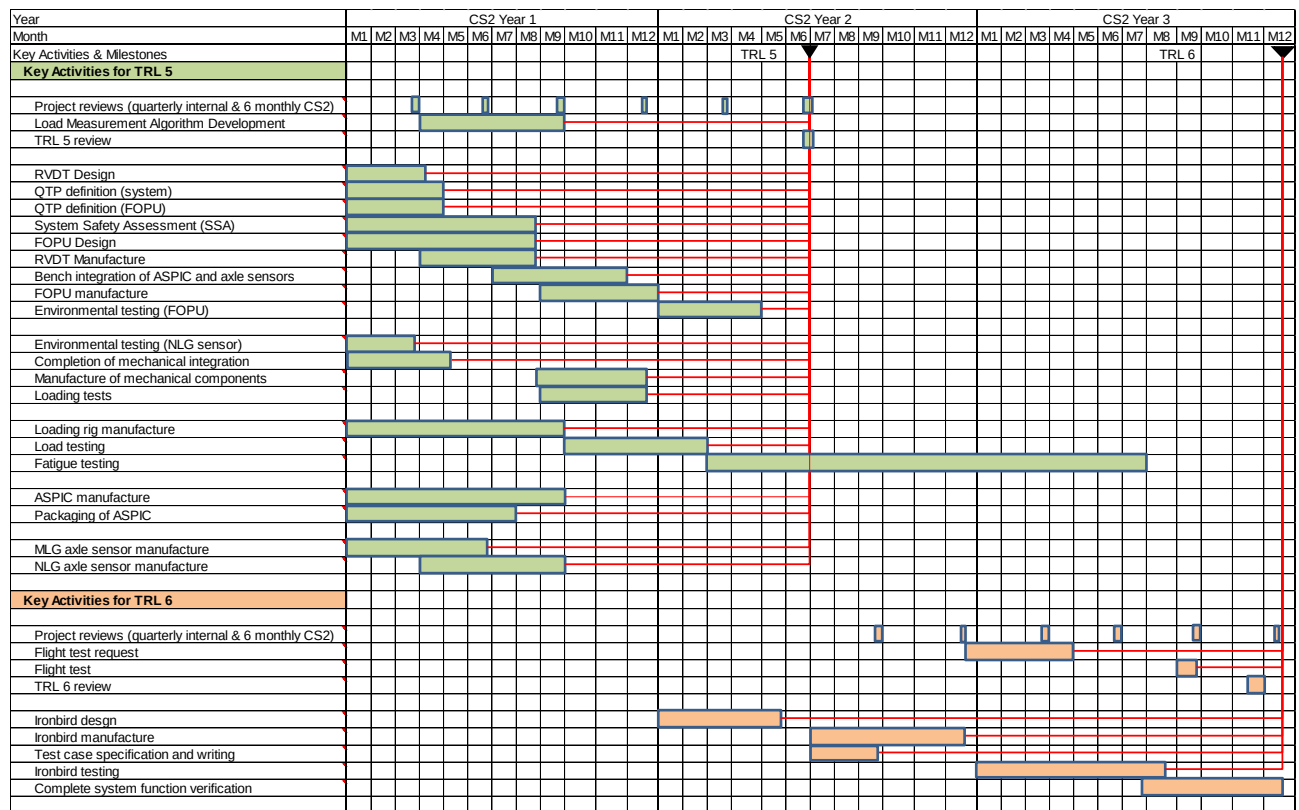
RVDT = Rotary Variable Differential Transducer

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
D03.05.01	NLG prototype sensor environmental testing	Test	Jul 2016
D02.01.01 D02.01.02	NLG & MLG sensor units for functional testing	Hardware	Jan 2017
D02.03.01 D02.03.02	FOPU units for performance testing	Hardware	Apr 2017
D03.05.02	FOPU environmental testing	Test	Aug 2017
D03.04.01	System (Iron-bird) Test Rig	Rig	Mar 2018
D03.06.01	System (Iron-bird) Testing	Test	Dec 2018
D04.03.01	Flight Test	Test	Mar 2019
	Test reports	Report	Regular intervals

Milestones			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
MIL	Milestone Review	MIL	Apr 2016
TRL5	TRL5 Review	TRL	Sept 2017
MIL	Milestone Review	MIL	Mar 2018
PRM	Project Reviews	PRM	Quarterly
TRL6	TRL6 Review	TRL	Apr 2019

The roadmap shown below gives an initial view of the schedule.



4. Special skills, Capabilities, Certification expected from the Applicant(s)

The main skills and capabilities required from the applicant are the following:

- System supplier with the skills required to design, integrate and certify aerospace systems.
- This includes performing system safety assessments, equipment environmental and fatigue testing as well as system functional testing.

The applicant shall demonstrate the capability and strong experience in developing high-tech integrated optronic devices capable of driving Fibre Bragg Gratings in an aeronautical environment.

They shall demonstrate a recognized skill in the development of highly integrated optronics and electronics at chip level. They shall have the skills to design optical strain measuring systems and manufacture them into a sensor suitable for the harsh landing gear environment.

The applicant shall have a robust experience in managing R&T new developments, from concept to ground tests in an aeronautical representative harsh environment, for both individual components, as well as for integrated systems.

The applicant shall have the capability to host a dedicated ground tests rig, able to integrate the several hardware and software components intended to be integrated in a large commercial aircraft landing gear.

III. **Analysis of centrifugal compressor instabilities occurring with vaneless diffuser, at low mass flow momentum**

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP Level 1 – MAJOR LOADS		
Estimated Topic Value (funding in k€)	900 k€		
Duration of the action (in Months)	48 months	Indicative Start Date	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-SYS-02-10	Analysis of centrifugal compressor instabilities occurring with vaneless diffuser, at low mass flow momentum
Short description (3 lines)	
The performance of compressors at low mass-flows is characterized by the occurrence of unsteady flow phenomena surge and rotating stall. These instabilities can cause noise nuisance and critical operating conditions with strong dynamical loading on the blades. Such phenomena must be detailed with the aim of applying a flow control strategy to enlarge the operating range and / or improve the stage performances.	

1. Background

Compressor stages using vaneless diffuser are known to have a wide operating range. However, at low mass flow rates, their efficiency extremely decreases because of flow separation and unsteady behavior inception. The occurrence of unsteady flow phenomena such as rotating stall or surge is a key problem for achieving a good working range of a centrifugal compressor. Rotating stall is characterized by the presence of one or several cells rotating around the annulus. It's known as a precursor of surge, which exhibits large amplitude oscillations of pressure through the whole compressor system.

The surge phenomenon constitutes a limit of the operating range and can strongly damage the stage or even destroy it. Moreover, even if the compressor stage can operate with a stable rotating stall at near surge operating points, the strongly unsteady features of the flow field lead to high pressure fluctuations on the blade. Consequences are a fatigue of the compressor and a probable reduction of its lifetime.

To anticipate it, or even try to avoid it, a detailed knowledge of the flow occurring at the limit of the operating range is necessary.

Surge phenomenon in centrifugal compressors has been studied for almost sixty years. Following the important work made on axial compressor by the motorists [1][2][3], most of the literature production focuses on vaned diffuser stages [4][5][6]. An effort would be necessary on vaneless diffuser cases, even if the scientific production is getting bigger this last decade [7][8][9]. Moreover, due to the various configurations found in the literature, a large spectrum of stall and surge behavior is reported and up to now, no overall rule can be given *a priori* concerning the instability inception in a given machine.

2. Scope of work

Tasks		
Ref. No.	Title - Description	Due Date
T01	Validation of the numerical approach on an academic open reference case	T0+24
T02	Surge inception on industrial case	T0+42
T03	Volute geometry impact on performances	T0+42
T04	Theoretical approach	T0+48

The first objective of the present study is to determine a surge inception scenario for a given industrial reference case of centrifugal compressor using vaneless diffuser and a non-symmetric Volute at outlet. Such a scenario must be based on a detailed numerical analysis supported by experimental results. Following the theoretical analyses carried out by Jansen [10], Senoo and Kinoshita [11], Tsujimoto *et al.* [12], Ljevar *et al.* [13], the second parts of the study aims at defining a 1D methodology able to predict the unstable modes and the associated frequency and rotational speed.

These 2 main objectives can be split up into 4 tasks:

- **T01: Validation of the numerical approach on an academic open reference case.**
The goal of this package is to determine the numerical model necessary to capture the unsteady feature of the flow at near surge (URANS, LES (...)). The given numerical protocol must be confirmed by experimental results.
- **T02: Experimental and numerical study of the surge inception on industrial case.**
On an industrial reference case provided by LTS (centrifugal wheel with vaneless diffuser), the aim of this package is to determine a surge inception scenario, using the numerical methodology obtained in WP1 coupled with experimental set up (unsteady pressure and mass flow measurement, PIV, (...)) as a complement.
- **T03: Volute geometry impact on performances**
The 3rd work package focuses on the Volute 3D geometry located at outlet, and its impact on the stage performances at low mass flow. The study especially targets the influence of the volute tongue and its contribution to stall inception by numerical means.
- **T04: Theoretical approach**
An analytical study based on linear or non-linear stability method, fed by the other tasks results, aims at predicting the unstable modes and the associated frequency and rotational speed early in the design process.
A second target of this task is to reduce the numerical set up to make it affordable in an industrial context (RANS, 2D simulations, (...)).

3. Major deliverables and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type	Due Date
D01	Numerical methodology	Report	T0+24
	Validation based on an academic test case	Report	T0+24
D02	Definition of the surge inception phenomenon on a given industrial case	Report	T0+42
	Main experimental results	Database	T0+42
	Main numerical results	Database	T0+42
	Numerical model (run file, mesh, post processing)	Files	T0+42
D03	Impact of the Volute geometry	Report	T0+42
	Numerical model (run file, mesh, post processing)	Files	T0+42
D04	Stability analysis on industrial test case	Report	T0+42
	Surge inception prediction methodology	Report	T0+48

4. Special skills, Capabilities, Certification expected from the Applicant

Skill 1 : Air Conditionning system / Turbomachinery / Centrifugal Compressor knowledge

Skill 2: Surge Inception

- Subsonic centrifugal compressor
- Centrifugal compressor using vaneless diffuser

Skill 3 : Instability analysis & Modelisation

Skill 4: Complex 3D unsteady CFD

Skill 5 : Complex unsteady measurements & analysis with difficult access

Skill 6: Description of the surge inception for integrated system

Capability 1 : CPU ressources, Hardware and software capability to deal with unsteady numerical simulations on complex 3D geometry (URANS / LES applied to turbomachinery)

Capability 2 : Experimental test bench (PIV, unsteady measurement, pneumatic turbomachinery) for subsonic centrifugal compressor

5. References

- [1] T. R. Camp and I. J. Day. *A study of spike and modal stall phenomena in a low-speed axial compressor*. *ASME Journal of Turbomachinery*, 120 :393{401, 1998.
- [2] K. Yamada, H. Kikuta, K Iwaliri, and M. Furukawa and S. Gunjishima. *An explanation for flow features of spike-type stall inception in an axial compressor rotor*. *Journal of Turbomachinery*, 135 :1{11, 2013.
- [3] S. Weichert and I. Day. *Detailed measurements of spike formation in an axial compressor*. *Proceeding of ASME Turbo Expo 2012*.
- [4] I. Trébinjac, N. Bulot, X. Ottavy, and N. Buffaz. *Surge inception in a transonic centrifugal compressor stage*. *Proceeding of ASME Turbo Expo*, GT2011-45116, 2011.
- [5] G. Pullan, A. M. Young, I. J. Day, E. M. Greitzer, and Z. S. Spakovszky. *Origins and structure of spike-type rotating stall*. *Proceeding of ASME Turbo Expo*, GT2012-68707, 2012.
- [6] Bousquet Y., 2014, *Modélisation et analyse des mécanismes impliqués dans l'apparition du pompage d'un étage de compresseur centrifuge*, *PhD Université de Toulouse*
- [7] Pavesi G., Dazin A., Cavazzini G., Caignaert G., Bois G. & Ardizzon G, 2013, *Experimental and Numerical Investigation of Unforced unsteadiness in a Vaneless Radial Diffuser*, *9th European Conference on turbomachinery – fluid dynamics and thermodynamics, Mars 2011, Turkey – pp. 625-636*

IV. Innovative design of acoustic treatment for air conditioning system

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP6 – Major Loads		
Estimated Topic Value (funding in k€)	600 k€		
Duration of the action (in Months)	36 months	Indicative Start Date	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-SYS-02-11	Innovative design of acoustic treatment for air conditioning system
Short description (3 lines)	
The objective of this study is to design a new acoustic treatment for air conditioning system, more specifically for a jet pump noise source. The innovative design should have a large absorption band of frequencies (100 Hz - 5000 Hz) with a small thickness and mass. The absorption shall be optimized with a special study of the noise source and a development of a specific modal detection (or antenna) adapted to the Topic Manager jet pump source will be set up.	

1. Background

The electrical air system is composed on an air jet pump or an electrical air fan that generates noise at the aircraft skin. High frequency noise reduction is achieved using passive treatment and some studies have been performed to improve the attenuation in middle and low frequencies with locally reacting materials. However, such solutions may be too heavy or thick for some industrial configurations, especially when low frequency attenuation is required. Some innovative solutions, highly efficient on an acoustic point of view, as well as light and compact, must therefore be developed.

The final objective is to progress with these new inovative acoustic solutions and optimize them for Topic Manager noise sources.

2. Scope of work

Tasks		
Ref. No.	Title - Description	Due Date
T1	Compact and low frequencies absorption concept proposal	T0+18
T2	<i>Implementation of a dedicated modal detection solution for jet pump noise source characterization</i>	T0+18
T3	<i>Prototypes manufacturing for laboratory and final system level tests</i>	T0+36

The work will be separated into three workpackages:

- **T1 : Compact and low frequencies absorption concept proposal**

The goal of this first task is to develop a numerical tool to optimize an impedance axially distributed. The concept must be compact (maximum thickness ~ 25 mm) and have a good absorption in low and middle frequencies (100 – 5000 Hz). This model should take into account a shear flow and a liner partitionning. The final proposal should be validated with numerical calculations.

- **T2 : Implementation of a dedicated modal detection solution for jet pump noise source characterization**

The goal of this task is to characterize the duct modal content of the Topic Manager noise source. The partner shall design and instrument microphones network adapted to the installation constraints (duct diameter of 173mm, high Mach flow ~ 0.3 , number of the Topic Manager microphone ~ 30) and should participate to measurements planned in the Topic Manager anechoic chamber. A first modal detection test campaign will be set up with the noise source only and will be the input to the numerical model and the concept proposal.

Information on the development of the modal detection network and its post processing should be shared with the Topic Manager. A technical guide to develop the post treatment will be written. The data will be post treated by the partner and shared with the Topic Manager. The duct modal decomposition tool should take into account both a sheared flow and lined walls.

- **T3 : Prototypes manufacturing for laboratory and final system level tests**

The concept proposal obtained at the end of T1 should be manufactured by the partner and tested in a laboratory in reduced scale configuration, in conditions representative of the industrial application:

- Duct flow $\sim M=0.3$
- Frequency range $\sim [100 - 5000]$ Hz
- Temperature $\sim 150^\circ\text{C}$

One prototype for system level test phase shall be provided at scale 1 for final tests in the Topic

Manager anechoic chamber. The final prototype shall be manufactured with a global low cost. It will have a cylindrical or conical shape. Regarding its dimensions, the diameter should be around 175 mm and its length around 400 mm. The prototype shall be able to handle skin temperature up to 200°C.

3. Major deliverables and schedule (estimate)

Deliverables			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
D1	Intermediate Progress Review		T0+12
D2	Development of new numerical tools and optimisation of innovative liner	Report	T0+18
D3	Design microphone network for Modal detection development and technical support to develop a post treatment	Report	T0+18
D4	Laboratory Prototypes fabrication and testing in laboratory	Prototype Available And Test Report	T0+24
D5	New innovative acoustic treatment concept validated by numerical calculations and tests	Report	T0+24
D6	Industrial process/assembly proposal	Report	T0+30
D7	Modal detection tool available	Tool Sent To Topic Manager	T0+24
D8	Jet pump modal detection without treatment	Test Report	T0+30
D9	Final prototype fabrication	Prototype Available	T0+30
D10	Jet pump modal detection with innovative liner	Test Report	T0+33
D11	Synthesis report	Report	T0+36

4. Special skills, Capabilities, Certification expected from the Applicant

Partners with significant experience in one the following areas (depending on the WP):

- Locally reacting acoustic material design and manufacturing
- Acoustic modelling/prediction of acoustic treatment performance
- Laboratory test with grazing flow
- Noise source detection in duct with flow and lined walls.

V. **Optimization of Cr free sealing process for thin SAA layers on AA2024 and implementation to other aluminium alloys**

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP 6 – MAJOR LOADS		
Estimated Topic Value (funding in k€)	250k€		
Duration of the action (in Months)	24 months	Indicative Start Date	Q2 2015

Identification	Title
JTI-CS2-2015-CFP02-SYS-02-12	Optimization of Cr free sealing process for thin SAA layers on AA2024 and implementation to other aluminium alloys
Short description (3 lines)	
The aim of this call is to find partner(s) able to optimize a Cr free (no Cr VI, no Cr III) sealing process for thin SAA layers on aluminium alloy AA2024 (sheets and machined samples), to implement this solutions to other aluminium alloys and up-scale the optimized solutions in an industrial scale.	

1. Background

Aluminium alloys are widely used in aeronautics applications. Nowadays, 95% of aluminium parts are protected by surface treatments in order to prevent corrosion. The surface treatment which is mainly used is Chromic Acid Anodizing coupled with its dichromate sealing (CAA), conversion coating (Alodine®) with or without painting and varnish. These protections contain the CMR compound Cr^{6+} or use it in their process (Cr^{6+} is used in the baths during the process, in the layer of conversion, in painting or in varnish). The Clean-Sky 2 programme aims at developing green technologies that meet the European regulation such as the REACH regulation.

Thin layer ($\leq 5 \mu\text{m}$) sealed Sulphuric Acid Anodising (SAA) is a good alternative process for replacing sealed CAA for **aluminium unpainted parts**. Previous studies on the anodizing process SAA and its Cr free sealing process performed within the topic manager background have already shown good results on one aluminium alloy (AA2024 sheets and machined). Process parameters for the anodizing SAA have been optimized and are fixed. Also, two sealing solutions demonstrated promising results, these solutions contains respectively 5 and 3 chemicals components in a given concentration. But the effects of each component, as well as the definition of their optimal concentration have not been studied. It also appeared during these previous studies that the implementation of a process optimized on one aluminium alloy (e.g. AA2024), to other aluminium alloys such as cast alloy AU5NKZr, is not obvious and requires complementary investigations.

The aim of this CfP is to find partner(s) that will propose a 2 years research program for developing thin layer **sealed** SAA coatings that will demonstrate good corrosion protection for aluminium unpainted parts. The main goal is to optimize the sealing processes previously developed for the given **thin layer SAA ($\leq 5 \mu\text{m}$)**. Especially the effect of each component of the 2 sealing solutions on the corrosion performance on AA2024 sheet and machined samples will be evaluated. And the concentration of the influent components, as well as the process parameters will be optimized taking into account the economic and environmental aspects. As a second step the full processes will be implemented on other substrates widely used by the topic manager: 2618, AU5NKZr, AS7G06. The final step will be the up-scaling of the processes in an industrial scale and the manufacturing of demonstrators (e.g. treatment of wheels, valve bodies...).

The defined parameters (for both SAA and the current sealing processes) will be shared with the partners as base for future work under an IPR agreement between the partners and the Topic Manager.

2. Scope of work

Tasks		
Ref. No.	Title - Description	Due Date
Task 1	Definition of the requirements	M2
Task 2	Optimization of the sealing parameters	M18
Task 3	Implementation of the optimized sealing solutions to other aluminium alloys	M24
Task 4	Industrial up-scaling and demonstrators	M24
Task 5	Characterisation of the samples and demonstrators	M24

Task 1 : Definition of requirements and definition of the solutions to be optimized:

At the beginning of the project, the topic manager will define the following requirements:

- Film properties : thickness and weight
- Corrosion resistance in SST, contaminants resistance, temperature resistance
- Fatigue properties
- Nature of alloys to be protected, including cast aluminium alloys AU5NKZr and AS7G06

The topic manager will share with the applicant the following informations:

- SAA parameters to be used
- Sealing solutions to be optimized: compositions and initial concentrations
- Parameters of the sealing process to be optimized : components, concentrations of components, pH, conditions used for rinsing / drying, temperature, etc.

Task 2 : Optimization of sealing parameters:

Task 2.1 : Effect of each components on the corrosion protection of AA2024 sheets and machined samples.

The aim of this sub-task is to define and understand what is the influence of each component on the **corrosion resistance** of AA2024 sheet and machined samples. Two sealing solutions will be studied, these solutions contain respectively 5 and 3 components. According to the results, the mechanisms involved in the corrosion protection will be then proposed.

Task 2.2: Optimization of the concentrations of components

According to the results of the task 2.1, the concentration of the components having strong effect on corrosion protection will be optimized. The study will be done on the 2 sealing solutions on AA2024 sheets and machined samples. For both solutions, the study of the baths stability and their ageing will be also performed.

Task 2.3: Optimization of sealing process parameters

The aim of this sub-task is to define the best process parameters for the 2 sealing solutions : pH, temperature, time, conditions used for rinsing and drying. The results of this sub-task will be used to define the best sealing solutions (concentration and process parameters optimized).

Task 2.4: Economic and ecological analysis

In this task, an economic and ecological analysis will be performed in parallel of task 2.2 and 2.3. These aspects will be taken into account for the optimization of the sealing processes.

Task 3: Implementation of the optimized sealing solutions to other aluminium alloys

The aim of this task is to study the sealing solutions, previously optimized on AA2024 (Task 2.3), on other aluminium alloys defined in Task 1. An adaptation / optimization would be probably necessary on the former alloys, especially on cast aluminium alloys AU5NKZr and AS7G06 which are very sensitive to corrosion and which have different behaviour than AA2024.

Task 4 : Industrial scale-up

This task will be performed in parallel of tasks 2 (subtasks 2.2 and 2.3) and 3 with an iterative method. Each optimized sealing solutions will be evaluated in a pre-industrial scale (first in small baths of 20-30L and then in larger baths of 200-300L) to check the reproducibility in a larger scale. The stability and ageing of the baths will also be evaluated at the industrial scale. Controls and following of baths will be also studied and proposed.

At the end of the project, the optimized sealing processes will be implemented in an industrial scale (1000L) and applied on demonstrators (wheels, valve bodies...).

Task 5 : Characterization of samples and demonstrators

The samples treated in task 2, 3 and 4 will be characterized in detailed by : SEM-EDX, FIB, contact angles measurements, Salt Spray Test (SST), Electrochemical analysis (Electrochemical Spectroscopy Impedance)...

The demonstrators treated in task 4 will be characterized in SST.

Fatigue properties will be evaluated by the Topic Manager on samples treated and provided by the partners.

The topic manager will provide all the samples required for the study.

3. Major deliverables and schedule (estimate)

Deliverables			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
D0.1	Minutes of KOM	R	M0
D1	Definition of the requirements (given by the Topic Manager)	R	M2
D0.2	Intermediate progress report	R	M12
D2.1	Optimization of sealing solution (components, concentration and process parameters)	R	M18
D2.2	Economic and ecological analysis	R	M18
D3	Implementation of the optimized solutions on other alloys	R	M24
D4	Industrial up-scaling	R and demonstrators	M24
D0.3	Final report	R	M24

4. Special skills, Capabilities, Certification expected from the Applicant

- Strong experience on surface technologies, especially on chrome free surface treatments (SAA, sealing processes)
- Strong experience and knowledge on the surface treatments of the following alloys : AS7G06 and AU5NKZr cast alloys, AA2618, and their corrosion behaviour after treatment and mechanisms involved.
- Strong experience in the industrial up-scaling on the aeronautical field
- Capacity and ability to implement in a pre-industrial and industrial scale, the processes developped during the project
- Capabilities required to performed the study :
 - o Laboratory (20-30L), pre-industrial (200-300L) and industrial (1000L) baths,
 - o SEM-EDX, FIB, XRD, contact angles measurement
 - o equipments for electrochemical analysis (especially Electrochemichal Spectroscopy Impedance)
 - o Salt Spray Test

VI. Analysis, validation and parametric studies of design and operating parameters for modern cabin ventilation concepts related to future aircraft energy management systems

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP 6.4		
Indicative Funding Topic Value (in k€)	2000 k€		
Duration of the action (in Months)	48 months	Indicative Start Date ⁵⁸	Q2 2016

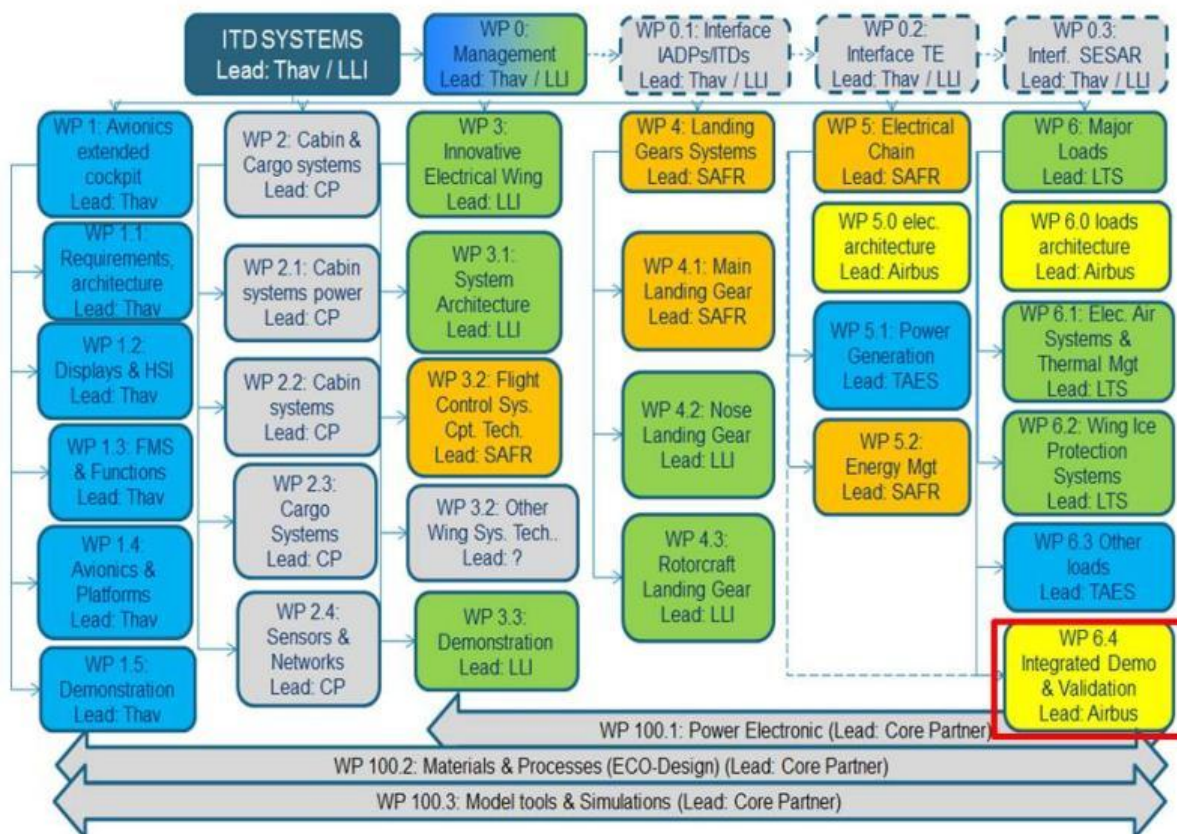
Identification	Title
JTI-CS2-2015-CFP02-SYS-02-13	Analysis, validation and parametric studies of design and operating parameters for modern cabin ventilation concepts related to future aircraft energy management systems
Short description (3 lines)	
Future aircraft energy management systems, aiming at smart management of electric power and thermal loads at system level, will substantially impact the cabin fluid- and thermodynamics. Due to the complex boundary conditions of cabin fluid- and thermodynamics, experimental validation at full scale in cabin mock-ups and demonstrators are required.	

⁵⁸ The start date corresponds to actual start date with all legal documents in place.

1. Background

In the context of advanced ECS and cabin ventilation there are potentially more degrees of freedom to achieve an energy optimized air conditioning operation. This includes steady state as well as transient thermal cabin behavior as well as an extended air management. The overall chain of the controlled system: ECS architecture – ECS operation & control – physical behavior of the cabin ventilation – occupant's thermal comfort perception needs therefore to be re-evaluated.

In this topic the special focus is on a sound and thorough investigation of the cabin ventilation and its analysis to provide the correct data for validation and verification of the control architecture.



2. Scope of work

Future ECS (Environmental Control System) concepts are using a new air intake (scoop) for supply of fresh air. The splitting of powering and ventilation makes it possible to use larger control ranges leading to potential variations in temperature and mass flows for an energy-related utilization. To exploit these operating ranges it is essential to gain a deeper understanding about the thermodynamic behavior of the cabin interior and indoor climate. In this context the distribution of CO₂ within the cabin is of fundamental interest.

The activities targeted by this call will take place in the frame of the Work package 6.4

The expected contribution from the applicant consists in three main tasks:

- Planning and design of a cabin mock-up in consideration of future long range aircraft concepts, based upon Airbus inputs
- Preliminary design and numerical optimization of the cabin ventilation system
- Experimental studies of cabin fluid- and thermodynamics related to future energy management systems

The high level planning of these tasks is the following:

Tasks		
Ref. No.	Title - Description	Due Date
T_6.4.5.1	Planning and design of a cabin mock-up in consideration of future long range concepts	T0+24 months
T_6.4.5.2	Preliminary design and numerical optimization of the cabin ventilation system	T0+30 months
T_6.4.5.3	Experimental studies of cabin fluid- and thermodynamics related to future energy management systems	T24+24 months

T_6.4.5.1: Planning, design and realization of a fully representative physical cabin mock-up in consideration of future long range concepts (twin aisle)

Special aspects to ensure detailed cabin fluid- and thermodynamic investigations have to be taken into account. The level of realism should be adaptable to guarantee the best price/performance ratio:

- Modern ventilation systems able to switch easily between various configurations.
- Highly precise control and measurement of relevant mass flows and temperatures
- Consideration of modern design principles and materials to recreate boundary conditions of a modern long range fuselage
- Compliance with modern, adequate measurement techniques (PIV, thermography, tracer gas, etc.)

T_6.4.5.2: Preliminary design and numerical optimization of the cabin ventilation system

Preliminary investigations on suitable, modern cabin ventilation configurations for future long range cabins (twin aisle) based upon Airbus inputs

- Unsteady CFD and cabin comfort simulations and investigations on appropriate and representative air flow systems
- Preselection of promising ventilation system design solutions, first integration and validation through mock up test.
- Based upon validation results, further optimization of models and components
- Numerical pre-examinations of the distribution of CO₂ inside the cabin by means of tracer analysis

Due to the very complex flow phenomena occurring in typical twin aisle cabin layouts (long range aircraft) in conjunction with modern ventilation methods, a profound validation of current numerical approaches has to be carried out.

T 6.4.5.3: Experimental studies of cabin fluid- and thermodynamics related to future energy management systems

Experimental investigations via the cabin mock-up of the flow- and temperature fields in a future long range twin aisle cabin considering state-of-the art and future cabin ventilation systems.

- Thermal passenger dummies for simulation of the cabin air flow with realistic obstructions, heat loads and buoyancy forces
- Up-to-date measurement techniques to obtain instantaneous information about the flow fields and to improve the understanding of the fluid physical processes
- Determination of temperature distributions
- Assessment of the heat removal efficiency on the basis of highly precise measurements of air temperatures as well as different adjusted mass flows
- Infrared thermography to survey the influence of the particular ventilation setting on interior surfaces
- Variation of mass flows and inlet temperatures (steady and spontaneous) to examine the effects on flow structures and temperature distribution the comfort relevant flow parameters and the heat removal efficiency
- Spontaneous temperature changes to detect storage effects due to the heat capacity of the cabin interior

Tracer gas analysis of the energetically most efficient configurations to determine the minimum possible mass flows to ensure cabin comfort requirements.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title – Description	Type	Due Date
D_6.4.5_1	Planning document for used measurement techniques and test matrix	R	T0+12 months
D_6.4.5_2	Design documentation of optimized components	R	T0+18 months
D_6.4.5_3	Cabin mock up	D	T0 +24 months
D_6.4.5_4	First validation results report	R	T0 + 33 months
D_6.4.5_5	Processed measurement data and final report	R	T0+48 months

Milestones (when appropriate)			
Ref. No.	Title – Description	Type	Due Date
M_6.4.5_1	Specification of requirements for a future long range cabin mock-up	RM	T0+3 months
M_6.4.5_2	Planning and design freeze for cabin mock-up	RM	T0+12 months
M_6.4.5_3	Mock-up and measurement techniques ready for testing, start of validation	RM	T0+24 months
M_6.4.5_4	First validation results	RM	T0+33 months
M_6.4.5_5	Optimized hardware available	RM	T0+39 months

Schedule:



*Type: R: Report - RM: Review Meeting - D: Delivery of hardware/software - M: Milestone

4. Special skills, Capabilities, Certification expected from the Applicant(s)

- Proven expertise in the establishment and operation of aircraft cabin mock-ups.
- Profound understanding of cabin fluid- and thermodynamics as well as passenger's comfort prediction.
- Proven know-how of computational fluid dynamic methods and processes for optimal efficiency on high-performance computer clusters.
- Proven expertise in the modeling of turbulent flows using high-fidelity RANS and cabin comfort models and scale-resolving approaches (hybrid RANS/LES, LES)
- Proven expertise in the modelling and optimization of cabin ventilation systems by means of experimental and numerical studies of turbulent flows.
- Proven know-how in the simulation of the heat input from human passengers on the basis of heated thermo dummies
- Proven expertise in the measurement of convective air flows on large scales in aircraft cabins by means of advanced Particle Image Velocimetry (PIV) techniques

5. Abbreviations:

PIV - Particle Image Velocimetry
RANS - Reynolds-averaged Navier–Stokes equations
LES - Large eddy simulation

VII. Electromechanical actuator for primary moveable surfaces of small aircraft with health monitoring

Type of action (RIA or IA)	IA		
Programme Area	SYS / SAT		
Joint Technical Programme (JTP) Ref.	WP 7.1 Efficient operation of small aircraft with affordable health monitoring systems WP 7.3 -Fly By Wire architecture for small aircraft		
Indicative Funding Topic Value (in k€)	1000 k€		
Duration of the action (in Months)	30 months	Indicative Start Date⁵⁹	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-SYS-03-01	Electromechanical actuator for primary moveable surfaces of small aircraft with health monitoring
Short description (3 lines)	
To test an available EMA up to failure. Based on the evaluation of failure conditions to identify technologies that improve EMA reliability in respect of any failure leading to an uncontrolled EMA position. Health monitoring and any other technology which do not require additional sensors and/or electromechanical devices are preferred. The initial tests have to be repeated on the improved EMA to demonstrate compliance with reliability requirements.	

⁵⁹ The start date corresponds to actual start date with all legal documents in place.

1. Background

During the last years in the context of more electric aircraft the development of EMA has increased rapidly. One of the main technical issues for implementing electromechanical actuator is the low reliability.

To overcome this problem one of the most promising approaches is to implement new technologies, including advanced monitoring system, both in term of safety and in economical affordable point of view.

The introduction of such technologies in the future EMA aims at reducing complexity and costs of a FBW (flight by wire) for SAT A/C control system through the use of a single EMA for a primary control surface.

Preferred technologies for the EMA are those that do not require adding new sensors / devices in the EMA.

The demonstrator prototype design of EMA needs to start from the analysis of failures identification and their progress as observed through a test programme carried out on existing actuator. These tests and the related analysis will allow building up a reference data base.

The same test program will be repeated on a new design of EMA integrating the proposed technologies in order to demonstrate that the identified failures are detected before they lead to a catastrophic condition. The main research focus is on the reliability of the electromechanical system. However, the partner is requested to make sure that failures occurring on the electronic control unit (ECU) are also not catastrophic.

2. Scope of work

The project will develop cost effectiveness technologies, including health monitoring, to improve the reliability of existing EMA that can be taken as reference for primary control surface application.

The project will be divided in the following tasks and milestones: identification of mechanical failures on existing EMA (T01 and T02); technologies identification to improve EMA reliability (T03); design and manufacturing of the innovative EMA (T04); verification test (T05).

Tasks		
Ref. No.	Title - Description	Due Date
T01	Test Bench definition The partner must provide for the test plan, to be agreed with the Topic Manager, an EMA/ECU and its test bench. The main characteristics of the EMA should close to the ones of the final EMA as requested by Topic Manager and described in Annex 1.	T0+2
T02	Running Test on existing EMA The partner must execute the test plan until mechanical failures occur. The test plan shall include endurance and environmental tests. Spare parts availability is required in order to identify multiple failures.	T2 to T8
T03	Technologies identification The partner in parallel with the tests execution of the available EMA/ECU shall present the technologies that intends to implement in the EMA + ECU to achieve the requirements. Effectiveness of each proposed technology have to be assessed and weighed in terms of impact on weight, size and cost of the EMA.	T2 to T10
T04	EMA design and manufacturing The partner shall develop the EMA / ECU and ensure the construction, assembly and preliminary testing of the assembly.	T10 to T22
T05	Running Test on innovative EMA The partner shall repeat on the new EMA / ECU the same tests performed at T01 and verify the effectiveness of the introduced technologies in order to identify the failures before they occur. The partner shall summarize the results of the test in a final report.	T22 to T30

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
D1	Existing EMA/ECU selection	R	T0+1
D2	EMA/ECU test specification and bench	R	T0+4
D3	EMA/ECU failures endurance test report	R	T0+8
D4	Innovative EMA/ECU technologies down selection	R	T0+10
D5	PDR of innovative EMA/ECU	RM	T0+13
D6	CDR of innovative EMA/ECU	RM	T0+18
D7	Innovative EMA/ECU manufacturing	D	T0+22
D7	Innovative EMA/ECU test report	R	T0+28
D8	Project final report	R	T0+30

Milestones (when appropriate)			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
M1	EMA/ECU failures endurance test report	R	T0+8
M2	Innovative EMA/ECU technologies down selection	R	T0+10
M3	PDR of innovative EMA/ECU	DR	T0+13
M4	CDR of innovative EMA/ECU	DR	T0+18
M5	Innovative EMA/ECU manufacturing	D	T0+22
M6	Innovative EMA/ECU test report	R	T0+28

*Type:

R: Report

RM: Review Meeting

D: Delivery of hardware/software

4. Special skills, Capabilities, Certification expected from the Applicant(s)

The Partner shall have:

- Previous experience in development and design of advanced technologies in the field of Electromechanical Actuation for Flight Control System.
- Proven experience in international R&T projects cooperating with industrial partners, institutions, technology centres, universities.
- Quality and risk management capabilities demonstrated through applications on international R&T projects and/or industrial environment
- Proven experience in the use of design, analysis and configuration management tools of the aeronautical industry
- Acknowledge participation to industrial air vehicle developments with experience in “in-flight” components and laboratory set-up for aeronautical certification.
- Electrical and mechanical installation and integration.
- Test rig design
- Instrumentation data acquisition, recording and monitoring.

5. Annex 1

The available EMA should have characteristics as close as possible to the use on small A/C.

Such characteristics are mandatory for the EMA with a detailed specification negotiated between Leader and selected partner

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ANNEX 1 SPECIFIC FOR AN EMA FOR SMALL AIRCRAFT

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Abbreviations

A/C	Aircraft
AGE	Aerospace Ground Equipment
ATP	Acceptance Test Procedure
AUC	Airborne, Uninhabited, Cargo
BIT	Built In Test
CBIT	Continuous BIT
DDP	Declaration of Design Performance
DRL	Data Requirement List
E3	Electromagnetic Environmental Effects
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
FCS	Flight Control System
FH	Flight Hours
FMECA	Failure Mode, Effects and Criticality Analysis
FRACAS	Failure Reporting Analysis and Correction Action System
FS	Flight Resident Software
GSE	Ground Support Equipment
ICD	Interface Control Document
I/O	Input /Output
LOF	Loss of Function
LRU	Line Replaceable Unit
MIL	Military Specification
MTBD	Mean Time Between Defects
OH	Operating Hours
PA	Primary Actuator
PUBIT	Power-Up Built-In Test
FCC*	Flight Control Computer

* As FCC, for the purpose of this call, it is intended the computer part of the test rig.

Units of Measure

The S.I. (System International) units of measurement will be used. The only exception to this regulation should be those units which have been accorded international recognition:

Altitude: Feet (Ft)

Rate of Climb: Feet /Minute (Ft/Min.)

Geographical Distance: Nautical Miles (1 nmile = 1852 m.)

Speed: Knots (Kts) (1Kt = 1 nmile/h)

1.1 Equipment Functional Description

The PA shall consist of an Electro-Mechanical Actuator (EMA) with an incorporated Electrical Control Unit (ECU). Provision for a separate ECU can be considered as an option.

The following requirements are meant to design the EMA and the associated ECU.

1.1.1 *Equipment Functional Requirements*

- The ECU shall provide digital interface to the FCC. Up to three digital interfaces are available for each ECU, coming from the three lanes of the interconnecting FCC.
- The ECU shall receive the actuator position command from the FCC through a digital data bus.
- The ECU shall perform the position control loop closure and command the EMA in order to pursue the command signal and to minimize the position error.
- The ECU shall acquire feedback signals from the EMA and use it for loop closure and for monitoring of EMA functionality. These signals can include position, speed, currents, temperature and all the information needed to comply to testability requirements.
- The information to be provided to the FCC shall include, as a minimum, EMA position, EMA current and status word. Signal redundancies have to be considered in order to achieve the reliability and safety requirements.
- The Fail-safe mode for the actuator shall be driven to midstroke position (equivalent to null surface deflection) and locked.
- The ECU shall provide the capability to put the EMA in Fail-Safe mode, in case of loss or invalidity of position demand from the interfacing FCC, power interruption or failure detection by its internal monitors.
- The ECU shall provide the capability to put the EMA in Fail-Safe mode in case of failure detection by the FCC monitoring logic, if requested by the interfacing FCC.
- Bus shall be RS422.
- Bonding, earthing, grounding and shielding, insulation resistance, dielectric strength, input and output protection of the EMA/ECU shall be in accordance with aerospace standard practice.
- Environmental conditions per DO160 G have to be considered for the design and test of the EMA/ECU.

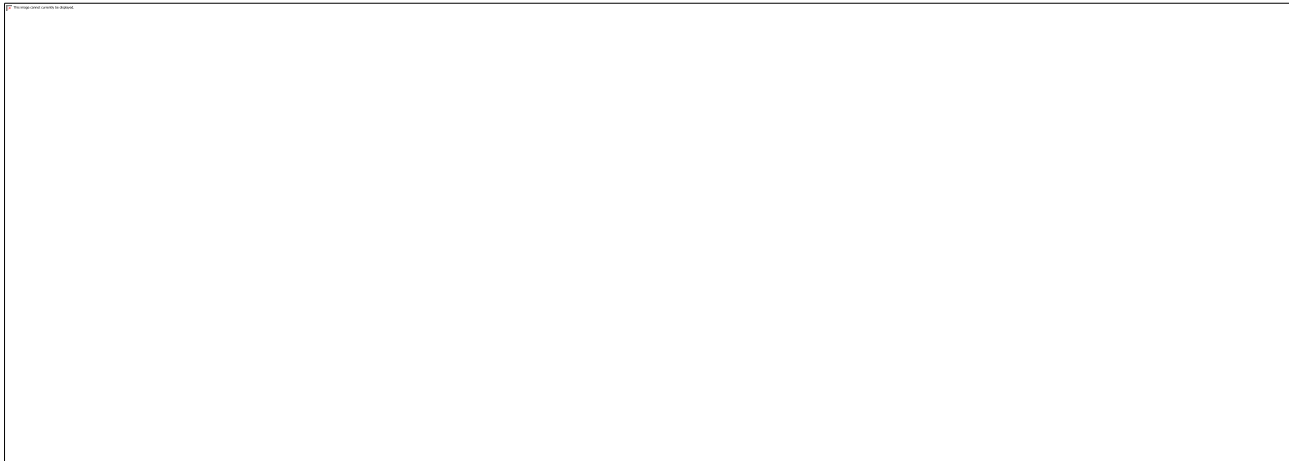
1.1.2 *Performance Requirements*

The main performance requirement has to be:

- Electrical stroke: 51.6 mm (+/- 25.8 mm); 90% life within +/- 5.2 mm
- Design Load (Max. Oper. Out of cycle): 1509 N
- Rated Load (continuous service): 248 N
- Design speed: 80 mm/s
- No load speed: 162 mm/s
- Radial load: 17% max
- Equivalent load (as per ISO 3408-5): 248 N + 31 N radial (12.4 %)
- Total stroke: $2.17 \cdot 10^7$ mm
- Useful Life: 15000 FH
- Positioning accuracy : Actuator static positioning accuracy (defined as the difference between the demanded position from Flight Control Computer and the actuator actual position), including backlash shall be, within all temperature range:

$$|2s \text{ Accuracy Error [mm]}| = \begin{cases} 0.4 & \text{for } 0 \leq |x| < 3 \\ 0.019x + 0.343 & \text{for } |x| \geq 3 \end{cases}$$

where x = Actuator linear position demand [mm]
 Requirement graphical explanation is reported in Figure below.



The Actuator shall comply with the frequency response requirements of Figure 1.1.2-1 and Table 13.1.2-1 with an applied load of 70% stall load $\pm$ 100% stall load/mm (i.e. 1368 N $\pm$ 1954 N/mm for the Elevator actuator), with actuator displacement equivalent to $\pm$ 1% surface deflection, as per the following table.

Input for the frequency response is the actuator position command from FCC (asynchronous transmission has to be accounted for); output for the frequency response is the actuator position (delay of feedback acquisition from position transducer has not to be accounted for).

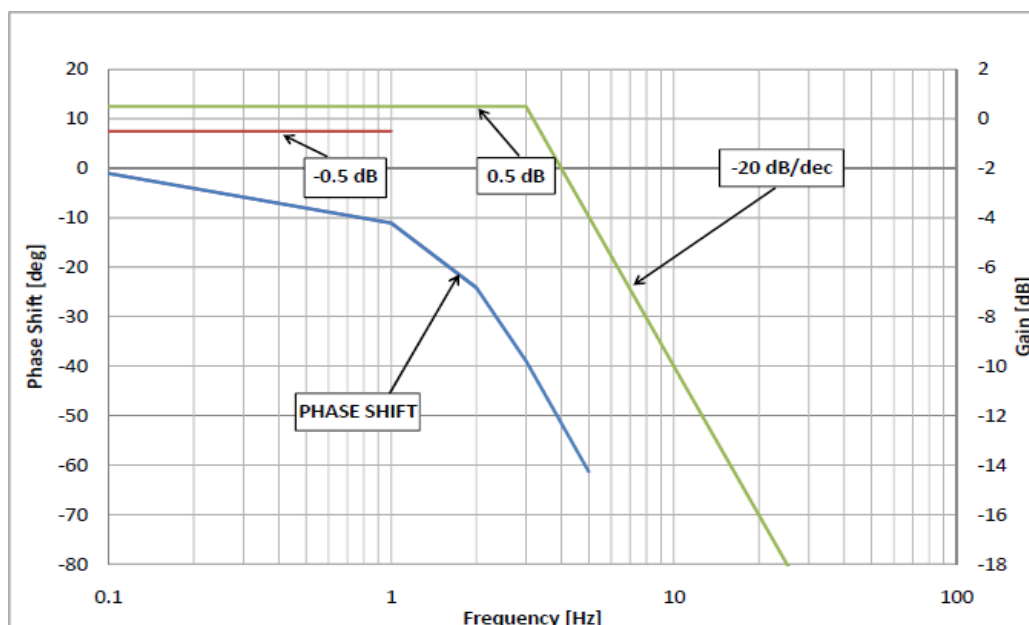


Figure 1.1.2-1 - Primary Actuator Dynamic Performance

Frequency [Hz]	Phase Loss [deg]
0.1	-1.0
1	-11.1
2	-24.2

3	-39.0
5	-61.4

Table 13.1.2-1 - Phase Loss requirement

1.1.3 *Power Input*

The Actuator shall meet the electrical power input requirements specified in Section 16 of DO-160G for Cat. ZX, except for Engine Starting Operation.

The Actuator shall be capable to operate without performance degradation when subjected to a 200 ms power interruption.

1.1.4 *Power Consumption*

The Max Normal Operation DC power consumption for the equipment, corresponding to a normal condition of voltage (28 V_{DC}) and ambient temperature (25°C), under a load equal to 10% of design (i.e. 1509 N) load defined hereinafter, shall not exceed 56W.

Maximum operating DC power consumption, under the worst conditions of voltage and environmental conditions, shall be defined by the Partner for Topic Manager agreement.

1.2 *Mechanical Interface*

1.2.1 *Installation and Mounting*

No pressurization system is provided on the A/C.

Partner shall provide mounting arrangements which enable the equipment to meet the Requirements.

The Partner shall define the installation tolerances in order to avoid impact on data accuracy (e.g. perpendicularity, incidence or any other requirement).

1.2.2 *Connections*

1.2.2.1 *Electrical System Connections*

The actuator electrical connectors shall be in accordance with MIL-C-38999 Series III, class F.

1.3 *Equipment Life*

1.3.1 *Useful Life*

Useful operational life of the actuator shall be not less than 15,000 Flight Hours without replacement or repair of major structural component. The relationship between Flight Hours and Operating Hours is 1 to 1.1.

The equipment performances shall be maintained within specified design limits for the entire equipment useful life. Component functional degradation life-dependant is to be addressed into design process to comply with the requirement. Sealant fixing and protection means for electronic equipment are to be included in the requirement.

1.4 Physical Characteristics

1.4.1 Dimensions

The Partner shall provide an outline drawing, detailing the dimensions of the unit to allow for mechanical, electrical and environmental installation.

The actuator dimensions shall be suitable for installation in the available envelope defined as L=300 mm, D=75 mm and H=200 mm. Load path is in “L” direction.

1.4.2 Mass

The mass of each PA shall not exceed 2.8 kg.

The Partner shall indicate the Center of Gravity of the actuator.

1.5 Reliability

Reliability shall be implemented in accordance with MIL-STD-785, tailored to meet the requirements of this specification.

1.5.1 Reliability Quantitative Requirements

1.5.1.1 Defect Rate

The actuator, after installation in the aircraft, shall achieve a total defect rate of 0.02 per 1000 Flight Hours (AUC).

Reliability shall be calculated using MIL-HDBK-217F or an equivalent method to be agreed.

Reliability shall be evaluated based on the following mission profile.

Mission Phase	Percentage	Temperature
A/C on Ground and T/O	5%	+70°C
A/C on Ground and T/O	2%	+85°C
Climb	6%	-15°C
Transfer and Loiter	78%	-45°C
Descent	6%	-15°C
Landing	3%	+50°C

1.5.2 Reliability Design Requirements

1.5.2.1 Electric/Electronic Component Derating

Design criteria shall be established such that all components used in the equipment are derated to achieve reliability requirements.

The Partner shall submit to Topic Manager the design criteria that will be adopted for the actuator design. Unless otherwise stated, the factors are those which apply when the ambient temperature around the component is 70°C and are related to the specified rating at that temperature.

1.5.2.2 Thermal Design

All electronic components shall be arranged so that, by optimizing the temperature loads, the maximum reliability is achieved.

Component packing shall be arranged to avoid hot spots.

Design, test and verification methods shall be based on MIL-HDBK-251A or equivalent.

All mechanical components shall be arranged and mounted so that, by optimizing the temperature of components, the maximum reliability is achieved.

The methods used shall be agreed by the Customer. For off the shelf equipment the Thermal Design requirements may be waived based on qualification and in service results.

1.6 Maintainability and Testability

1.6.1 Maintainability General Requirements

The design of the actuator shall be based on minimum scheduled maintenance consistent with safe and economic operation. Scheduled maintenance is only permitted when an action is necessary to prevent a safety hazard, or on grounds of economy to preclude expensive damage.

- Each requested scheduled exception shall be based on the Reliability Centered Maintenance procedures (MIL-STD-1843, MSG-3 or equivalent).
- The actuator shall be designed to comply, where applicable, with the maintainability design requirements of MIL-STD-1472F, Section 5.9.
- The actuator shall be designed to achieve the highest possible level of Maintainability and Testability with emphasis on eliminating requirements for Aircraft Ground Equipment (AGE) and special tools.
- The use of Special to Type Test Equipment (STTE) or of Automatic Test Equipment (ATE) shall be avoided, or at least minimized and, in any case, shall be subjected to agreement with the Purchaser.
- Reason for introducing AGE, ATE, STTE and special tools shall be justified.
- The actuator shall preclude improper installation, mounting, alignment or connection of other LRU's, assemblies, subassemblies, modules, components, cables or lines, e.g. by provision of suitable access and appropriate reference marks.
- The actuator, where applicable, shall utilize modular design with a module designed on functional block bases that facilitates repair and easy functional check-out for location of failures to LRU at

Organizational level and to a module at Intermediate Level.

- It shall be possible to remove and replace any module without disturbing any other module or affecting the LRU wiring.
- Following replacement of the actuator, post installation testing shall be limited to BIT check.
- Standards shall be established for maximum diagnostic confidence, minimum maintenance times and user alignment of test equipment for development and in service use.
- Flight line (organizational) level inspections and servicing shall be optimized to ensure minimum expenditure of time, a minimum of specialized skills, special tools and support equipment.
- Selected connectors shall be designed and mounted to provide maximum ease of connector's access and replacement, to facilitate removal and installation of equipment, to eliminate the danger of cross-connection and to achieve maximum standardization.
- Internal connector cable lengths shall be adequate to ensure easy repair/replacement of connectors without major breakdown.

1.6.2 *Maintainability Specific Requirements*

1.6.2.1 *Maintenance*

The equipment shall be designed to be kept Operational or restored to Operational status with a three levels maintenance concept: Organizational, Intermediate and Depot. A two levels maintenance concept may also be employed, if cost effective.

1.6.2.2 *Servicing*

Considering the failure-free condition, the time to perform all checks envisaged to start any operation shall be less than 2 min, including in this time all prescribed checks/inspections and tasks and all start-up and interruptive (if any) Built-In-Tests (BITs).

1.6.2.3 *Scheduled Maintenance*

The actuator components shall be maintained following the «On-Condition» and «Condition Monitoring» policies.

Where there are airworthiness or economic reasons for introducing life to overhaul, or scheduled maintenance intervals, then the approved frequencies shall be not less than 300 Flight Hours or 12 months for minor periodic inspections and 3600 Flight Hours for major (depot) inspections.

1.6.2.4 *Unscheduled Maintenance*

The repair time on-aircraft of the actuator shall not exceed 12 minutes. Repair time includes all the time required to verify and isolate the failure, remove and replace the failed LRU, and verify a successful repair. Repair time does not include the time required to gain access to the LRU on the aircraft.

The Partner shall state for approval what repairs are possible off-aircraft on the actuator and the relevant Mean Time To Repair figures.

1.6.3 *Testability General Requirements*

Testing of the equipment shall be performed according to the following test concept, categorized for

maintenance level:

- Operational level: failure identification and isolation;
- Maintenance flight-line level: failure location, equipment restoration;
- Maintenance Intermediate level: failure location at module/sub-LRU level, LRU restoration;
- Depot level: failure identification at lower level and item restoration.

The general Testability requirements of MIL-HDBK-2165, Appendix A and B shall apply.

The testability shall be based on the following concept employing both continuous and initiated testing: functional monitoring during operation; detection of failures as they arise prior to flight during pre-flight safety checks; diagnostic for maintenance on-aircraft to detect and isolate main component faults.

The configuration of continuous monitoring, on-ground check frequency, relevant BIT sequences and test procedures shall be established by the Partner as specific testability requirements.

The design of test features shall permit accurate, decisive and repeatable measurement of functional characteristics. The features may be represented by hardware and software.

Maximum use shall be made of Built-in Test (BIT) features to accomplish failure detection and failure isolation without assistance of support equipment.

The actuator shall incorporate power-up and continuous BIT facilities to perform on-ground and In-flight BIT monitoring.

The BIT shall include the following functions:

- Fault monitoring;
- Internal and External redundancies management and failure recording;
- Warnings, cautions & failures signal provision.

Fault monitoring shall insure that all input and output functions, safety critical circuits and electrical power forms are operating within tolerance and safeguarded from permanent damage.

1.6.3.1 Built in test general requirements

The Built In Test (BIT) features shall accomplish failure detection and failure isolation, at least to LRU level without assistance of support equipment.

Any requirement for external test equipment shall be justified, taking in due consideration the logistic support criteria.

For modular LRUs fault location shall have the following performances (using proper test equipment):

- Failure located within 1 module 90 %
- Failure located within 2 module 95 %
- Failure located within 3 modules 99 %

Failures in the test circuitry shall not cause secondary failures and shall not affect the performance of the equipment.

No failure in the BIT circuits shall cause an erroneous "GO" indication at the end of the PUBIT unless it can be shown that the probability of this condition is compatible with the overall integrity objectives of the equipment.

1.6.3.2 Testability Specific Requirements

BIT function shall include the following functionalities:

- Power-Up Built-In Test (PUBIT): a BIT automatically initiated on power-on and comprising purely electronic checks.
- Initiated Built-In Test (IBIT): a BIT initiated by personnel action to check both the electronic and the servo-actuation.
- Continuous Built-In Test (CBIT): a BIT that automatically runs in the background to check a limited number of critical parameters.
- Maintenance Built-In Test (MBIT): the most exhaustive of all BITs. It is manually engaged for maintenance, diagnostic and serviceability testing in order to detect and isolate failures.

The pre-flight safety check procedures, by means of visual inspections as well as of integrated Built In Test features and operators initiated actions, shall detect, isolate and locate 100% of the predetermined failures defined within the safety critical and mission critical functions in section 3.3.6.

The equipment monitoring and testing (PUBIT, CBIT and IBIT) shall be designed to detect, isolate and locate at least the 95% of all the predetermined failures.

The equipment false alarms rate shall not exceed 1% of the total number of the predetermined failures affecting functions or performance.

1.6.3.2.1 Power-Up Built-In Test (PUBIT)

The PUBIT shall verify the correct functionality of the actuator and include tests of all electrically monitored functions and redundancies in order to avoid the failure accumulation within infrequently used circuits. Interlocks shall be provided to prevent in-flight engagement and to terminate PUBIT when the conditions for engagement no longer exist, unless it can be demonstrated that in-flight operation does not adversely affect equipment functionality.

The PUBIT shall be initiated automatically each time the actuator is electrically powered up.

The PUBIT shall comprise purely electronic checks.

The time to test by means of the automatic PUBIT sequence shall be in accordance with the “Warm-up” section.

1.6.3.2.2 Initiated Built In Test (IBIT)

IBIT shall be initiated on pilot request before flight.

Interlocks shall be provided to prevent in-flight engagement and to terminate IBIT when the conditions for engagement no longer exist, unless it can be demonstrated that in-flight operation does not adversely affect equipment functionality.

1.6.3.2.3 Continuous Built-In Test (CBIT)

The CBIT shall be performed automatically during normal operation.

CBIT shall be performed continuously during normal operations and non-intrusively (without interfering with the normal operation of the equipment).

CBIT shall not present any safety hazard and shall not initiate any non-reversible process.

The Partner shall define all continuous monitoring and self-tests required to provide maximum feasible failure detection.

The CBIT shall detect and isolate 100% of the predetermined failures within the safety critical functions defined in section 3.3.6 “Safety”.

The CBIT shall detect and isolate 95% of the electronic monitored function failures.
The false alarms rate, for fault detection, shall not exceed 1%.

1.6.3.2.4 Maintenance Built-In Test (MBIT)

The MBIT shall execute performance measurements and fault localization on the actuator by using ground test equipment where applicable, for the detection and location of failures during maintenance operations. These tests shall verify that no pre-determined failures exist and that system tolerances are within the specified limits.

The MBIT, by using ground test equipment where applicable, shall be performed when it is required to investigate:

- flight critical functions in accordance with the time at risk specified in paragraph 3.2.4.4.5.
- every section of the equipment which cannot be checked by the BIT automatic routine and/or which operate interactively with other aircraft systems.

A mean to rig the actuator to within the required limits (if applicable) after installation on the aircraft shall be provided.

Interlocks shall be provided to prevent in-flight engagement and to terminate MBIT when the conditions for engagement no longer exist.

In order to avoid the accumulation of possible latent failures, it shall be possible to detect, at all maintenance levels, the 100% of the predetermined failures.

1.6.3.2.5 Time at risk

The time at risk is defined as the period in flight hours between two successive checks in which it is possible to identify a dormant failure, or the period after test at which the aircraft is at risk.

Any failure which is detected only by the PUBIT shall have an effective period of risk of 24 hours between the start of mission and the next PUBIT (i.e. the mean size of all the expected mission profiles).

Where a latent failure can be found only by performing a diagnostic maintenance check at Organizational/Intermediate Maintenance (OM/IM) level, the risk period shall be assumed to be 300 Flight Hours, which is assumed to be the mean time between Organizational/Intermediate Maintenance activities. For latent failures which can be found Off-Aircraft only at Depot Maintenance (DM) level, the equipment MTBF shall be assumed as the risk period and the required check shall be phased with the Aircraft's major inspection intervals.

1.7 Safety

1.7.1 Flight Safety Requirements

The determination of the hazard probabilities herein specified shall consider the probability of occurrence of all failures in the components which are part of the equipment.

The analyses for flight safety compliance performed by the Partner shall consider latent failures both passive and active, the associated time at risk and the effects of detected and undetected failures.

The Partner shall provide data about the PA to support Probability of Loss Of Control (PLOC) calculation of the entire Flight Control System.

- I. Failures causing loss of surface control/function or damped position for each primary actuation system shall have a probability of occurrence less than $1E-7$ fail/FH.
- II. Structural failures resulting in free floating or excessive backlash for the actuation system shall have a probability of occurrence less than $1E-7$ fail/FH.
- III. Failures causing surface runaway, hardover, uncommanded movements or oscillations for each primary actuation system shall have a probability of occurrence less than $1E-8$ fail/FH.
- IV. Failures causing surface jam for the actuation system shall have a probability of occurrence less than $1E-8$ fail/FH.
- V. Failures described at III and IV shall have a probability of occurrence less than $1E-9$ fail/FH in case a single point of failure exists.

VIII. Passive thermo-acoustic insulation for small aircraft

Type of action (RIA or IA)	IA		
Programme Area	SYS / SAT		
Joint Technical Programme (JTP) Ref.	WP 7.5.1 [Multifunction thermo-acoustics insulation of cabin for small aircraft] WP 7.5.3 [Thermal comfort in cabin for small aircraft]		
Indicative Funding Topic Value (in k€)	400 k€		
Duration of the action (in Months)	36 months	Indicative Start Date⁶⁰	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-SYS-03-02	Passive thermo-acoustic insulation for small aircraft.
Short description (3 lines)	
Preparation of small testing specimens of basic insulation materials (passive system of insulation) and their testing in lab, development of the composites for optimal insulation, preparation of small testing specimens of this composite, testing this composites in lab, development and production of reference demonstrator (without optimization), development and production of demonstrator (optimized according to new results)	

⁶⁰ The start date corresponds to actual start date with all legal documents in place.

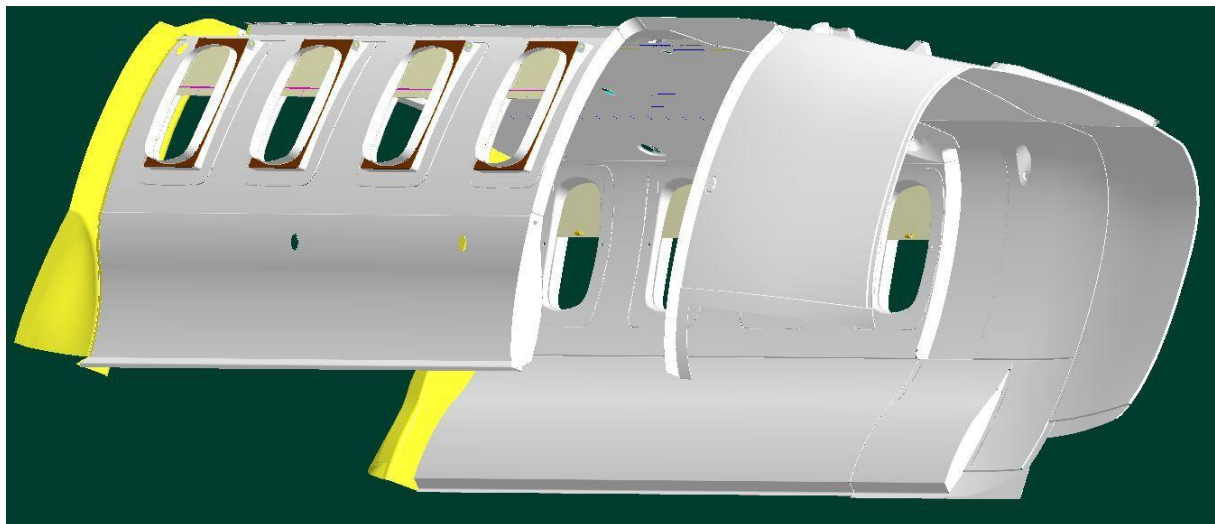
1. Background

This CfP is focused on searching (and development) new materials for noise and thermal insulation. The aim is the development of new insulation composites (multilayer system), which will be suitable for different noise or thermal loads.

The problematic of noise and thermal insulation for small turbo propeller aircraft is still important for manufacturers and strongly affects passenger comfort, safety and partially operational cost. This project is focused on research on the acoustic and thermal problems inside small aircraft. Main objectives are the development of new material structures and design suggestions based on the principles of passive insulation on the walls of aircraft. It is expected that this development will fulfil economic and strategic aims of this project, namely safety and higher flight comfort inside fuselage for crew and passengers.

Research and development methods must be oriented to the final design considering material characteristic (structures, weight, flammability or self-extinguishing capability, adhesive system of insulation layer, thermal stability, etc.) and managing the steps of future manufacture (low price, certificate or test protocols according to FAR/CS 23, etc.)

The proposed project will contribute to WP 7.5.1 - Comfortable and safe cabin for small aircraft - and the results will be used in WP 7.5.3 Thermal comfort in cabin for small aircraft.



1) Working area for development of passive acoustic and heat insulation - whole interior of small aircraft (circa 28 m²)

2. Scope of work

The activities proposed in this CfP are focused on the development of optimized passive noise and heat insulation. The project includes the following tasks: survey on the theoretical background for noise and heat testing in laboratory conditions; definition and analysis of optimal standards for aerospace processes; selection of final test methods and test devices in laboratory conditions and selection of appropriate materials. Based on these achievements, the project will continue with testing samples with different material characteristics, optimized material design, systems and technology steps to realization, preparation of samples and their specific testing in accordance with FAR/CS 23.

The project will then focus on the installation of the selected insulator demonstrators directly on the interior panels of small aircraft, provided by topic leader.

Tasks		
Ref. No.	Title - Description	Due Date
T1	Material selection and development for passive heat control.	T0 + 2 month
T2	Material selection and development for passive noise control.	T0 + 3 month
T3	Selection and development of optimized material combination for passive heat and noise control - synergy effects.	T0 + 5 month
T4	Selection of optimal method for laboratory testing of samples.	T0 + 6 month
T5	Selection of optimal type and geometry samples for laboratory tests, test planning.	T0 + 9 month
T6	Testing of samples (basic commercial materials for standard level of acoustic and heat values).	T0 + 10 month
T7	Design and calculating thicknesses of layers for passive insulation for different noise and heat loading.	T0 + 13 month
T8	Proposal of samples for testing of passive insulation and for different noise and heat loading.	T0 + 15 month
T9	Analyses/validation of tests for separate samples, selection of proper method for testing of composite samples.	T0 + 17 month
T10	Preparation of test plan for composite/sandwiches materials.	T0 + 18 month
T11	Testing of samples with final material properties composite /sandwiches structures.	T0 + 23 month
T12	Design of demonstrator with sound and heat insulation (present application type).	T0 + 30 month
T13	Manufacture of demonstrator with sound and heat insulation (present application type).	T0 + 36 month
T14	Design of demonstrator with sound and heat insulation for specific parts of frame inside fuselage of aircraft (with concretely specific request of fuselage – humidity in the joint of wing and fuselage; soft and drought joint between insulation panels and airframe)	T0 + 30 month
T15	Manufacture of demonstrator with sound and heat insulation for specific parts of frame inside fuselage of aircraft.	T0 + 36 month

3. Major deliverables and milestones

Deliverables			
Ref. No.	Title - Description	Type	Due Date
D1	Typical materials research study and selection of materials for testing (T1 – T3)	R and RM	T0 + 4 month
D2	Research study of optimal testing methods and type of samples (T4 – T5)	R	T0 + 4 month
D3	Test and test evaluation progress report (T7)	R and RM	T0 + 10 month
D4	Test report and calculating review (T7 – T10)	R and RM	T0 + 17 month
D5	Production and technological documentation, detailed material specification (certification according to FAR/CS 23 included) (T12)	TD	T0 + 21 month
D6	Production and technological documentation, detailed material specification (certification according to FAR/CS 23 included) (T14)	TD	T0 + 30 month
D7	Demonstrator of normal passive insulation (T15)	D	T0 + 36 month
D8	Production and technological documentation, detailed material specification (certification according to FAR/CS 23 included) (T14)	TD	T0 + 30 month
D9	Demonstrator of optional passive insulation (T15) – (TRL 3-4)	D	T0 + 36 month
D10	Delivery of sample series used for design of demonstrator	TD	T0 + 36 month

*Type: R: Report - TD: technical documentation - RM: Review Meeting - D: Delivery of hardware/software

Milestones			
Ref. No.	Title - Description	Type	Due Date
M1	Final selection of basic materials for testing of acoustics and heat values	R and RM	T0 + 4 month
M2	Review for preparation of test methods (focused on heat and acoustic values according to standards)	RM	T0 + 10 month
M3	Agreement of selected materials for design samples (acoustic and heat requests)	RM	T0 + 12 month
M4	Technological documentation of preparation of composite insulation layers and results of calculation methods (heat transfer, analyse of acoustic values), for passive insulation, steps for optimisation heat insulation layers	RM	T0 + 24 month
M5	Test plan, technical request for real testing of normal and optimal passive insulation considering heat transfer.	RM	T0 + 36 month

General Schedule

Time schedule of research and tests	2016				2017				2018			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Selecting of basic insulation materials												
T1 - Material selection for passive heat control												
T2 - Material selection for passive noise control												
T3 - Selection of optimal material combination for passive heat and noise control												
Testing of basic and commercial materials for noise insulation lab												
T4 - Selection of optimal method for laboratory testing of samples												
T5 - Choose of optimal type and geometry sample for laboratory testing, creating of test plane												
T6 - Testing of samples (basic materials).												
Simulation of materials and their structure as passive noise and heat insulation												
T7 - Design and calculating thicknesses of layers for passive insulation and different Noise and												
T8 - Proposal of sample for testing of passive insulation and for different Noise and Heat loading												
T9 - Analyse of tests for separate samples, choose of method for testing of composite samples.												
T10 - Preparing of test plan for composite / sandwiches structure.												
T11 - Testing of samples with finally composite/sandwiches structures												
Normal passive insulation (no optimization - present application type)												
T12 - Design of demonstrator with sound and heat insulation (present application type)												
T13 - Manufacture of demonstrator with sound and heat insulation (present application type)												
Passive noise and heat control with optimal structure for particular parts of aircraft												
T14 - Design of demonstrator with sound and heat insulation for specific parts of frame inside fuselage of aircraft												
T15 - Manufacture of demonstrator with sound and heat insulation for specific parts of frame inside fuselage of aircraft												

4. Special skills, Capabilities, Certification expected from the Applicant(s)

- Library, theoretical background and knowledge focused for activity in aircraft and aerospace industry (mechanical and practical skills with small machine parts)
- FAR, JAR and ISO standards – knowledge and orientation in the problematic of international standards for aircrafts, concretelly CS/FAR 23
- Orientation in processes focused on certification or test review according to standarads FAR, JAR, ISO, EN and DIN – thypical knowledge in testing, metrology and material science.
- Knowledge and practical experience with development polymer materials or polymers systems

ANNEX 1 – Scope of work

Testing of basic and commercial materials for noise insulation lab

T4 - Selection of optimal method for laboratory testing of samples

- Theory background for testing of noise and heat in laboratory condition
- Finding standards for aerospace processes
- Selecting of finally test method and devices in laboratory condition
- Will be valid for both tests (base and multilayer materials)

T5 - Choose of optimal type and geometry sample for laboratory testing, creating of test plane

- Creation of optimal geometry for measurement in laboratory according to standards
- Preparation of test samples and devices for measurement
- Time schedule of test and results

T6 – Testing of samples

- Definition of sizes, geometry, and material structure for manufacturing of samples
- Order of material structure by companies focused on specialized manufacture of porous materials
- Selection and creating samples testing in laboratory
- Conditioning according to standards for aircraft industry
- Test plan separately methods (noise and heat)

Simulation of materials and their structure as passive noise and heat insulation

T7 - Design and calculation of thicknesses of layers for passive insulation and different noise and heat loading.

- Calculation of optimal thicknesses for concretely application inside fuselage of aircraft
- Selection of thicknesses and adding adhesive layers on the surfaces of samples
- Processes of modelling and calculating of dynamic changes in software and calculating programs

T8 - Proposal of sample for testing of passive insulation and for different noise and heat loading.

- Preparation of samples depending on different flying regime
- Determine of specific noise and heat loading for samples (frequency, mechanical pressure, sound pressure, temperature, thickness etc.)

T9 - Analyse of tests for separate samples, choose of method for testing of composite samples.

- Exploration of choose methods for testing of composite structures
- Definition of sizes, geometry, and material structures for manufacturing of samples- Finding new steps according to standards and application of this step on selected materials
- Solution for specific test steps and application of composite materials

T10 - Preparing of test plan for composite/sandwiches materials.

- Test plan and time schedule

T11 - Testing of samples with finally composite/sandwiches structures

- testing of composite and sandwiches structure in laboratory condition
- Test focused on noise and heat parameters
- Values: sound absorption coefficient, transmission coefficient, reflection coefficient, frequency analyse, transmission damping (mechanical), transmission of Heat, mechanical resistivity, adhesion of layers (peel tests) etc.

Normal passive insulation (no optimization - present application type)

T12 - Design of demonstrator with sound and heat insulation (present application type)

- Design and creating of type demonstrator according to standards and recommended request
- Specific and tips parameters thickness, porous volume etc.
- Estimated insulation surface – interior of small aircraft (circa 28 m²)

T13 - Manufacture of demonstrator with sound and heat insulation (present application type)

- Manufacturing of concretely type demonstrator according to standards and recommended request
- Specific and tips parameters thickness, porous volume etc.

- Insulation will be installed mostly on interior panels (will be ensured by Evektor) or aircraft frame (will be ensured by Evektor)

Passive noise and heat control with optimal structure for particular parts of aircraft

T14 - Design of demonstrator with sound and heat insulation for specific parts of frame inside fuselage of aircraft

- Design of parts for frame
- Design of surface geometry demonstrator
- Optimal material structure, adhesives parts and geometry according to request of aircraft frame
- Estimated insulation surface – interior of small aircraft (circa 28 m²)

T15 - Manufacture of demonstrator with sound and heat insulation for specific parts of frame inside fuselage of aircraft.

- Manufacturing of parts for frame
- Design of surface and recommending geometry for finally demonstrator
- Optimal material structure and geometry according to request of aircraft frame
- Insulation will be installed mostly on interior panels (will be ensured by Evektor) or aircraft frame (will be ensured by Evektor)
- Technology of adhesive process of passive insulation on the walls of fuselage

IX. Database of dynamic material properties for selected materials commonly used in aircraft industry

Type of action (RIA or IA)	IA		
Programme Area	SYS / SAT		
Joint Technical Programme (JTP) Ref.	WP 7.5.2 – Advanced crashworthy seat		
Indicative Funding Topic Value (in k€)	300 k€		
Duration of the action (in Months)	13 months	Indicative Start Date⁶¹	Q2 2016

Identification	Title
JTI-CS2-2015-CFP02-SYS-03-03	Database of dynamic material properties for selected materials commonly used in aircraft industry.
Short description (3 lines)	
The aim of this CfP is to develop a test methodology (Including design & manufacturing of specimens), and to perform testing of the material specimens in order to create a database of selected materials with a sufficient range of material properties to be used in computer simulation of crash behaviour.	

⁶¹ The start date corresponds to actual start date with all legal documents in place.

1. Background

Currently, the process to prove compliance of crashworthy seats for small aircrafts (certified under FAR//CS-23 regulation) is mainly based on testing of the final seat with a high probability of failure and repetition of test. This makes the process of proving the compliance excessively expensive. The most effective way to lower the costs is the inclusion of simulation of the seat crash behaviour in the design process. Current software tools provide a wide range of simulation possibilities, suitable for this topic.

In order to perform the simulation of complex crash behaviour of aircraft seat with results close to the real behaviour during crash test, among other parameters, high speed dynamic material properties have to be used.

The mentioned material properties are not currently publicly accessible for basic aircraft material selection. Therefore, there is a need to create such a database which provides high speed dynamic material properties. In the scope of CS2, a database of material dynamic properties will be created and presented as part of the output obtained from WP 7.5.2. - Crashworthy seat, which is part of WP 7.5 - Comfortable and safe cabin for small aircraft.

This CfP will secure at the least a TRL, within WP 7.5.2.

2. Scope of work

Tasks		
Ref. No.	Title – Description	Due Date
T1	Typical material overview and selection of materials for testing	T0+2 month
T2	Dynamic material testing research study	T0+2 month
T3	Test specification including design of test specimens with technical documentation	T0+4 month
T4	Manufacturing of specimens	T0+8 month
T5	Test, test evaluation and creation of database	T0+13 month

	Months												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Dynamic material properties database for common materials used in aerospace industry													
Typical material overview and selection of materials for testing													
Dynamic testing regulation research study													
Test specification including design of test specimens with technical documentation													
Manufacturing of specimens													
Test, test evaluation and creation of database													

T1 - Typical material overview and selection of materials for testing

The main aim of this task is an extensive research study of materials typically used in aerospace with focus on aircraft seats and energy absorbers installed to the typical seat designs.

Based on the research study, a selection of materials for the database of dynamic material properties will be made. List of materials intended for testing will contain about 12 materials (Al, steel, composite, plastics, etc.), but the decision about the final number of tested materials will be made after negotiation between an applicant and the leader.

The applicant must consult the leader in the selection of initially proposed materials and for the selection of materials to be actually tested.

T2 - Dynamic material testing research study The aim of this task is to prepare a brief research study about the possibilities and regulations for the dynamic material testing. This study will be served as a basis for the material test specification.

T3 - Test specification including design of test specimens with technical documentation

The aim of this task is to create the test specification for testing of material dynamic properties and to design the tested specimens. The expected strain rates range from $5s^{-1}$ to $500s^{-1}$. The crash test of the small aircraft seat (not subject of this call) is performed in a range from 8 m/s to 14 m/s.

According to the research study from T2, specimens for testing will be designed. The technical documentation in form of drawings will be created for the specimens.

T4 - Manufacturing of specimens

This task is focused on manufacturing of specimens according to the technical documentation created in T3. The applicant shall ensure manufacturing of specimens for all required materials.

T5 - Test, test evaluation and creation of database

In this task, the applicant shall perform high speed tensile tests of material specimens. Result evaluation will be performed and output will be provided in terms of stress/strain curves suitable as inputs for various FE dynamic analysis systems.

The results will be summarized in the material dynamic property database.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
D1	Research study of typical material and selection of materials for testing	R and RM	T0+2 month
D2	Research study of regulations for dynamic testing	R	T0+2 month
D3	Test specification and specimen design progress report	R	T0+3 month
D4	Test specification, test specimen drawings	R and RM	T0+4 month
D5	Specimen manufacturing progress report	R	T0+8 month
D6	Test and test evaluation progress report	R	T0+11 month
D7	Test evaluation report and material dynamic property database	R	T0+13 month

*Type: R: Report - RM: Review Meeting - D: Delivery of hardware/software

Milestones (when appropriate)			
<i>Ref. No.</i>	<i>Title - Description</i>	<i>Type</i>	<i>Due Date</i>
M1	Final selection of materials for testing	R and RM	T0+1 month
M2	Final test specification and approved technical documentation for specimens	R	T0+4 month
M3	Manufactured specimens and launch of testing	RM	T0+11 month
M4	Material dynamic property database	R	T0+13 month

4. Special skills, Capabilities, Certification expected from Applicant(s)

- Testing equipment dedicated for high speed tensile testing with a capacity sufficient to test specimens in strain rates ranging from 5 s^{-1} to 500 s^{-1} and speed ranging from 5 m/s to 15 m/s.
- Extensive experience in high speed tensile testing for dynamic material behaviour evidenced by references.
- Experience in manufacturing of test specimens in-house or in cooperation.