Annex VI:
6th Call for Proposals (CFP06) -
List and Full Description of Topics

Call Text
[R3]

- 15 March 2017 -

Revision History Table		
Version n°	**Issue Date**	**Reason for change**

R3	15 March 2017	Final Release for Participation Portal. Please note the following revisions:
		▪ Clerical error in the Summary table p.7: Titles of the following Call Topics revised as follows:
		    ○ JTI-CS2-2017-CFP06-LPA-03-09 “Image based landing solutions for Disruptive Cockpit concept”
		    ○ JTI-CS2-2017-CFP06-LPA-03-11 "Multimodal HMI development tools"
		▪ Call Topic “JTI-CS2-2017-CfP06-FRC-01-15: Interactional aerodynamic assessment of advanced Tilt Rotor configuration” further improved following the SRG Consultation of January 2017 and early questions/comments received during the Brussels info day in February 2017
		▪ Call Topic “JTI-CS2-2017-CfP06-SYS-02-29: System Modelling and Algorithm design” removed from CfP06 and as a result, the following items are revised accordingly:
		  ○ Index Chapter (pp. 3-5)
		  ○ Call Overview (p. 5)
		  ○ List of Topics for Calls for Partners (CFP06) (pp. 7-11)
		  ○ Identification Codes of the following SYS Call topics (pp. 473-500) and as follows:
		    - JTI-CS2-2017-CfP06-SYS-02-29 “High density energy storage module for an electric taxi”
		    - JTI-CS2-2017-CfP06-SYS-02-30 “Innovative pump architecture for cooling electrical machine”
		    - JTI-CS2-2017-CfP06-SYS-02-31 “Power module”
		    - JTI-CS2-2017-CfP06-SYS-02-32 ”Development of functionalizable materials”
		    - JTI-CS2-2017-CfP06-SYS-02-33 “Development of autonomous, wireless, smart and low cost current sensor for monitoring of electrical lines”
		    - JTI-CS2-2017-CfP06-SYS-02-34 “Optical hot air leak detection system proof-of-concept development”

Important notice on Q&As

Question and Answers will open as from the Call Opening date via the Participant Portal of the European Commission.

In case of questions on the Call (either administrative or technical), applicants are invited to contact the JU using the dedicated Call functional mailbox: Info-Call-CFP-2017-01@cleansky.eu

Note: questions received up until 28th April 2017, 17:00 (Brussels Time) will be answered after analysis and published in Q&A when appropriate. In total, three publications of Q/As are foreseen:
16th March, 10th April and 17th May 2017 (estimated dates).

The Q/As will made available via the Participant Portal of the European Commission.

Index

Overview of number of topics and total indicative funding value per SPD

Area	No. of topics	Total indicative topic funding value (in M€)
IADP Large Passenger Aircraft	17	15,48
IADP Regional Aircraft	2	2,00
IADP Fast Rotorcraft	11	11,05
ITD Airframe	17	14,15
ITD Engines	14	15,77
ITD Systems	13	10,35
Small Air Transport (SAT) Transverse Area*	[2]	[1,6]
ECO Transverse Area	0	0,00
Technology Evaluator	0	0
TOTAL	**74**	**68,80**

*2 SAT Topics launched in the following areas: ENG and SYS

Note: Figures in brackets indicate that these activities are identified as having benefits for the Transverse Areas i.e. SAT and ECO Design but which launch and budget reside inside the concerned SPDs and not in the Transverse Areas as such.

List of Topics for Calls for Partners (CFP06)

Identification Code	Title	Type of Action	Value (Funding in M€)	Topic Leader
JTI-CS2-2017-CfP06-LPA-01-29	Modelling of installed jet noise for UHBR engine integration with forward flight effects	RIA	0,50	Airbus
JTI-CS2-2017-CfP06-LPA-01-30	Test Cell Control System for NPE Demonstrator	IA	0,75	SAFRAN
JTI-CS2-2017-CfP06-LPA-01-31	Representative HLFC Leading Edge structure – Torsion and Bending Stiffness Test	IA	0,50	Aernnova
JTI-CS2-2017-CfP06-LPA-01-32	Insect contamination investigations and mitigation	IA	1,50	Airbus
JTI-CS2-2017-CfP06-LPA-01-33	Multi-physics modelling of elementary physical phenomena applied to an innovative high temperature engine valve	IA	1,10	Liebherr
JTI-CS2-2017-CfP06-LPA-01-34	3D printing and harsh environment testing of flow control actuators at aircraft scale	IA	0,55	Airbus Group Innovation
JTI-CS2-2017-CfP06-LPA-01-35	Innovative compact heat exchangers modelisation & characterisation	RIA	1,50	Liebherr
JTI-CS2-2017-CfP06-LPA-02-16	SmartContainer	IA	2,00	Airbus
JTI-CS2-2017-CfP06-LPA-02-17	Glass fiber based temperature/air humidity and Agent detection sensors & measurement systems	IA	0,48	Fraunhofer
JTI-CS2-2017-CfP06-LPA-02-18	Multi-Physics methodology for phase change due to rapidly depressurised two-phase flows	RIA	0,40	Fraunhofer
JTI-CS2-2017-CfP06-LPA-02-19	High performance Body Landing Gear fittings	IA	0,40	Airbus
JTI-CS2-2017-CfP06-LPA-02-20	Manufacturing oriented solution keel beam	IA	0,60	Airbus
JTI-CS2-2017-CfP06-LPA-02-21	Development of systems for automated testing in the aircraft interior	IA	1,00	Fraunhofer
JTI-CS2-2017-CfP06-LPA-03-09	Image based landing solutions for Disruptive Cockpit concept	IA	1,70	Airbus
JTI-CS2-2017-CfP06-LPA-03-10	Avionics Technologies Management solution for Pilot Workload Reduction	IA	1,40	Airbus D&S
JTI-CS2-2017-CfP06-LPA-03-11	Multimodal HMI development tools	IA	0,60	Honeywell
JTI-CS2-2017-CfP06-LPA-03-12	High density Electrical connectors	IA	0,50	Zodiac Aerospace
JTI-CS2-2017-CFP06-LPA		**17 topics**	**15,48**	
JTI-CS2-2017-CFP06-REG-01-09	Innovative Low Power De-Icing System	RIA	1,20	Leonardo Aircraft
JTI-CS2-2017-CFP06-REG-01-10	E2-EM Supervisor and Control Algorithms	RIA	0,80	Leonardo Aircraft
JTI-CS2-201-CFP06-REG		**2 topics**	**2,00**	

Identification Code	Title	Type of Action	Value (Funding in M€)	Topic Leader
JTI-CS2-2017-CfP06-FRC-01-13	Low-speed Air Data Sensor for Tilt-rotor Control	IA	0,75	Leonardo Helicopters
JTI-CS2-2017-CfP06-FRC-01-14	Contactless measurement system for real time monitoring of proprotor flapping angle	IA	1,00	Leonardo Helicopters
JTI-CS2-2017-CfP06-FRC-01-15	Interactional aerodynamic assessment of advanced Tilt Rotor configuration	RIA	2,20	Leonardo Helicopters
JTI-CS2-2017-CfP06-FRC-02-20	Lateral rotor noise prediction dedicated to low noise footprint optimisation of a compound helicopter	RIA	0,80	Airbus Helicopters
JTI-CS2-2017-CfP06-FRC-02-21	Emergency Exits and Cabin Footstep for the Fast Rotorcraft	IA	0,70	Airbus Helicopters
JTI-CS2-2017-CfP06-FRC-02-22	Lateral rotor declutching mechanism for a fast compound rotorcraft	IA	0,90	Airbus Helicopters
JTI-CS2-2017-CfP06-FRC-02-23	Enhanced gear strength through cavitation peening technologies	IA	0,40	GE Avio
JTI-CS2-2017-CfP06-FRC-02-24	Hybrid bearings technologies	IA	0,60	GE Avio
JTI-CS2-2017-CfP06-FRC-02-25	Fuel System Detail Development, Testing and Manufacturing	IA	1,50	Airbus Helicopters
JTI-CS2-2017-CfP06-FRC-02-26	Compound Rotorcraft Assembly Tooling	IA	0,70	Airbus Helicopters
JTI-CS2-2017-CfP06-FRC-02-27	Rotor's Flight Test Instrumentation on demonstrator Fast Rotorcraft Project	IA	1,50	Airbus Helicopters
JTI-CS2-2017-CFP06-FRC		**11 topics**	**11,05**	
JTI-CS2-2017-CfP06-AIR-01-25	Prediction of aerodynamic loads at high Reynolds Number	RIA	1,90	Dassault Aviation
JTI-CS2-2017-CfP06-AIR-01-26	Development of innovative and optimized stiffeners run-out for overall panel weight saving of composite wing	RIA	0,75	Dassault Aviation
JTI-CS2-2017-CfP06-AIR-01-27	Innovative solutions for metallic ribs or fittings introduced in a composite box to optimally deal with thermo-mechanical effects	RIA	0,75	Dassault Aviation
JTI-CS2-2017-CfP06-AIR-01-28	Optimized cockpit windshields for large diameter business aircrafts	IA	0,90	Dassault Aviation
JTI-CS2-2017-CfP06-AIR-01-29	Optimisation of Friction Stir Welding (FSW) and Laser Beam Welding (LBW) for assembly of structural aircraft parts	RIA	1,40	SAAB
JTI-CS2-2017-CfP06-AIR-02-39	Integration of innovative ice protection systems into structure and their validation	RIA	1,20	Airbus Defence & Space
JTI-CS2-2017-CfP06-AIR-02-40	Enhanced Low Cost Complex Composite Structures.	IA	0,50	Airbus Defence & Space
JTI-CS2-2017-CfP06-AIR-02-41	Integrated electronics for actuator data and power management for Morphing Leading Edge activities	IA	0,45	Fraunhofer

Identification Code	Title	Type of Action	Value (Funding in M€)	Topic Leader
JTI-CS2-2017-CfP06-AIR-02-42	Lay-up tools for net-shape AFP-manufacturing of geometrically complex helicopter sideshell sandwich-panels	IA	0,40	Fraunhofer
JTI-CS2-2017-CfP06-AIR-02-43	Low cost optical wave guides for damage detection including analysis and aircraft data transfer related to aircraft functional needs with self-testing connection	RIA	0,85	Airbus
JTI-CS2-2017-CfP06-AIR-02-44	Adjustable high loaded rod	IA	0,40	Airbus
JTI-CS2-2017-CfP06-AIR-02-45	Development and deployment of PLM Tools for A/C Ground Functional testing with Eco-design criteria.	RIA	0,40	Airbus Defence & Space
JTI-CS2-2017-CfP06-AIR-02-46	Auto testing technologies and more automated factories for Aircraft validation test process	RIA	0,40	Airbus Defence & Space
JTI-CS2-2017-CfP06-AIR-02-47	Part specific process optimization in SLM	RIA	0,60	Fraunhofer
JTI-CS2-2017-CfP06-AIR-02-48	Development and validation of a portable, automated and jigless system for drilling and assembly of fuselage joints	IA	0,90	Leonardo Aircraft
JTI-CS2-2017-CfP06-AIR-02-49	Development and validation of a self-adaptive system for automated assembly of major composite aerostructures	IA	2,00	Leonardo Aircraft
JTI-CS2-2017-CfP06-AIR-02-50	Prototype Tooling for subcomponents manufacturing for fuselage.	IA	0,35	FIDAMC
JTI-CS2-2017-CFP06-AIR		**17 topics**	**14,15**	
JTI-CS2-2017-CfP06-ENG-01-15	Bearing chamber in hot environment	RIA	1,70	Safran
JTI-CS2-2017-CfP06-ENG-01-16	Torque measurement in turbofan	IA	1,00	Safran
JTI-CS2-2017-CfP06-ENG-01-17	Advanced turbine system performance improvement through dual-spool rig tests	IA	1,10	GE
JTI-CS2-2017-CfP06-ENG-01-18	Development of innovative methods and tooling for machining of slender shafts	RIA	0,40	GKN
JTI-CS2-2017-CfP06-ENG-01-19	Thermoplastic Thrust reverser cascade	IA	0,45	Safran
JTI-CS2-2017-CfP06-ENG-01-20	Long Fiber Thrust reverser cascade	IA	0,45	Safran
JTI-CS2-2017-CfP06-ENG-01-21	Aerothermal characterization in the engine compartment	RIA	0,90	Safran
JTI-CS2-2017-CfP06-ENG-01-22	Advanced Instrumented Engine cradle of the Turboprop demonstrator	IA	0,40	Safran
JTI-CS2-2017-CfP06-ENG-03-15	IP Turbine Rear Stages Aero/Noise Rigs	IA	2,25	ITP
JTI-CS2-2017-CfP06-ENG-03-16	Development of non-intrusive engine emissions instrumentation capability	IA	2,00	Rolls-Royce

Identification Code	Title	Type of Action	Value (Funding in M€)	Topic Leader
JTI-CS2-2017-CfP06-ENG-03-17	VHBR Engine – Journal Bearing Technology	RIA	3,00	Rolls-Royce
JTI-CS2-2017-CfP06-ENG-03-18	Development of capability to understand & predict sub-idle & idle behaviour of geared VHBR engines	RIA	1,02	Rolls-Royce
JTI-CS2-2017-CfP06-ENG-03-19	Intermediate Compressor Case Duct Aerodynamics	RIA	0,50	GKN
JTI-CS2-2017-CfP06-ENG-04-07	Advanced investigation of ultra compact RQL reverse flow combustor	IA	0,60	Avio
JTI-CS2-2017-CFP06-ENG	**14 topics**		**15,77**	
JTI-CS2-2017-CfP06-SYS-01-04	Manufacturing process for ultimate performance inertial MEMS Accelerometer	IA	1,50	Thales
JTI-CS2-2017-CfP06-SYS-01-05	Solutions for voice interaction towards natural crew assistant	IA	1,10	Thales
JTI-CS2-2017-CfP06-SYS-01-06	Affordable Electro-Optical Sensor Cluster/Assembly Unit(LRU) for Vision & Awareness enabling Enhanced Vision, Sense & Avoid, and Obstacle Detection Systems for Aeroplane and Helicopter All-weather Operations and enhanced safety	IA	1,50	SAAB
JTI-CS2-2017-CfP06-SYS-02-29	High density energy storage module for an electric taxi	IA	0,80	Safran
JTI-CS2-2017-CfP06-SYS-02-30	Innovative pump architecture for cooling electrical machine	IA	0,80	Thales
JTI-CS2-2017-CfP06-SYS-02-31	Power module	IA	0,50	Thales
JTI-CS2-2017-CfP06-SYS-02-32	Development of functionalizable materials	IA	0,60	Safran
JTI-CS2-2017-CfP06-SYS-02-33	Development of autonomous, wireless, smart and low cost current sensor for monitoring of electrical lines	IA	0,90	Safran
JTI-CS2-2017-CfP06-SYS-02-34	Optical hot air leak detection system proof-of-concept development	IA	0,40	Liebherr
JTI-CS2-2017-CfP06-SYS-03-09	Computing Node for Safety Critical Applications	IA	1,00	Piaggio
JTI-CS2-2017-CfP06-SYS-03-10	Electrocoating process for Cr6-free surface treatment of aluminium parts	IA	0,35	Liebherr
JTI-CS2-2017-CfP06-SYS-03-11	Screening and development of optimized materials (wires, potting resins and impregnating varnishes) for high temperature coils	IA	0,50	Liebherr
JTI-CS2-2017-CfP06-SYS-03-12	Assessment of Partial Discharge and breakdown behaviour of electric insulation materials for very high voltage gradients	RIA	0,40	Liebherr
JTI-CS2-2017-CFP06-SYS	**13 topics**		**10,35**	

1. Clean Sky 2 – Large Passenger Aircraft IAPD

I. Modelling of installed jet noise for UHBR engine integration with forward flight effects

Type of action (RIA or IA)	RIA		
Programme Area	LPA		
Joint Technical Programme (JTP) Ref.	WP 1.1.1		
Indicative Funding Topic Value (in k€)	500		
Topic Leader	Airbus	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	48	**Indicative Start Date**[1]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-LPA-01-29	**Modelling of installed jet noise for UHBR engine integration with forward flight effects**
Short description	
Build and validate a physics-based model of installed jet noise with forward flight effects for UHBR engine integration.	

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

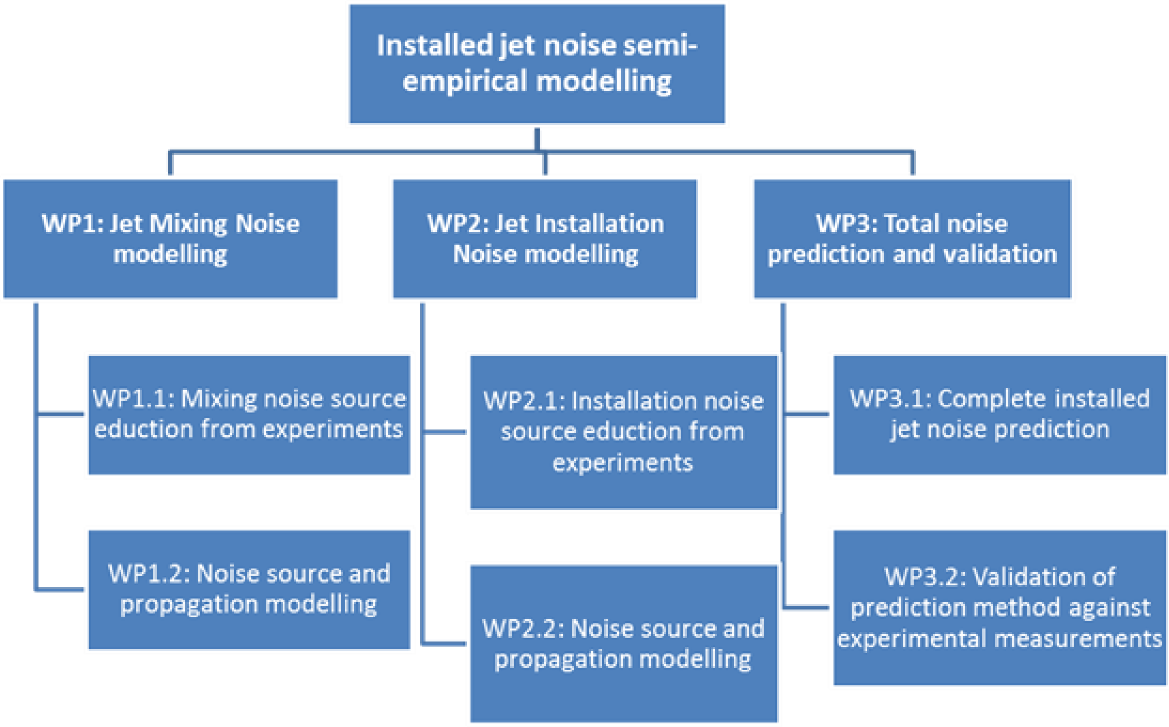
1. Background

For future products targeting year 2025 – 2030 for Entry Into Service, both Aircraft and Engine manufacturers work together on new Engine technologies aiming at achieving significant reduction of Specific Fuel Consumption. One proposed solution is the development of Contra-Rotating Open Rotors (CROR) Engine technology. Improved Ducted Turbofan Engine are an alternative solution to move towards ambitious SFC reduction goal and are more suitable for large airplanes with higher cruise speed requirements. To improve the efficiency of this type of power plant, it is mandatory to improve both cycle efficiency and propulsive efficiency.
In order to keep the same level of thrust, the reduction of jet velocity is compensated by increasing mass flow, therefore the fan/nacelle diameter and increase of ByPass Ratio (ratio of bypass or fan duct mass flow over core duct mass flow). The Ultra High Bypass Ratio (UHBR) Engine concepts are defined as BPR>12, are featuring an increased diameter and a reduction of nacelle length to minimize additional weight and drag drawbacks.

Due to other constraints like ground clearance (distance between nacelle lowest point and ground during landing), the installation of the engine with regard to the wing will lead to increasingly close-coupled architectures. The nozzle exhaust may be in the close vicinity of the wing leading edge. As a result, the jet mixing will interact strongly with the wing and/or the flaps during take-off and landing phases.

In terms of impact on aircraft noise, one of the main issue resulting directly from the significant exhaust diameter increase and new close-coupled architectures is the Jet Installation Noise. On the one hand, the jet mixing noise from the isolated nozzle (without wing influence) is expected to decrease due to jet velocity reduction. On the other, the strong jet-wing aero-acoustic interaction and the presence of the flight stream will modify the jet plume and the associated noise sources and radiation. The overall installed jet noise will then be composed of jet mixing noise and jet installation noise.

Industry needs to assess installed jet noise in flight conditions for the close-coupled UHBR architectures. Projects such as JERONIMO (EU FP7) have been applying simulation methods and semi-empirical models to capture the trends for both noise sources. Numerical simulations based on turbulence-resolving CFD can cope with flight conditions but with a long-return time and remain expensive for parametric studies. Semi-empirical models are strongly required for engineering, but these methods are currently limited to static conditions. The main objective of this work is, as a follow-up of JERONIMO, to progress on modelling the installed jet noise in flight conditions with fast-return semi-empirical methods.



2. Scope of work

The main objective is to model the integration of UHBR turbofan engine jet noise with interactions with wing structures and flight effects. A major opportunity is to increase the representativity of the modeling to evaluate aircraft certification noise and operational external noise.

The technical need is to model both the aft directivity of jet noise in the far field, and the pressure fluctuations in the jet near field that are responsible for jet-wing/flap interaction noise (installation noise). The frequency ranges of interest for the modelling are indicated in terms of Strouhal number St_D based on jet diameter and mean exhaust velocity: St_D = 0.2 to 10, with a high priority on St_D = 0.2 to 2.

The challenge will be to develop and validate simplified models for both source and propagation, with proper simulation of forward flight flow. Peculiar attention must be paid to the generation of a relevant and high-quality experimental database in laboratory jet noise wind tunnel. This database should include the influence of flight velocity and of the external boundary layer. An important requirement is that jet noise source models capture how the presence of a wing body modifies the noise sources in the jet. This wing body may be approximated by flat plates and/or airfoils with gradually increasing complexity.

WP1 – Jet Mixing Noise modelling

WP1.1 – Mixing noise source eduction from experiments [M0- M0+18]
Aerodynamic and acoustic measurements will be performed on simplified cases simulating the UHBR engine exhaust. Advanced measurements of turbulence and pressure fluctuations will form a state-of-the-art aeroacoustic database on canonical cases. When flight simulation is on, the external nacelle boundary layer will be characterized and its influence will be assessed. WP1.1 and WP2.1 are expected to share the same measurements.
The most important parameters for a model for jet mixing noise source in flight conditions will be

educed from the measurements.

WP1.2 – Mixing noise source and propagation modelling [M12- M36]
The source model educed from WP1.1 will be used jointly with a propagation model to obtain jet mixing noise radiation in the far field with account for the effect of forward flight.

WP2 – Jet Installation Noise modelling

WP2.1: Installation noise source eduction from experiments [M0 - M0+24]
Similarly as for WP1.1, the most important parameters for a model for jet installation noise source will be educed from the measurements. Different scenarii will be envisaged with respect to the interaction between the propulsive jet and the wing model: wing in linear pressure field, jet flow grazing on wing, jet flow impacting wing. The test matrix will include the flight effect and the presence of a simplified wing body.

WP2.2: Installation noise source and propagation modelling [M0+18 - M0+36]
The source model educed from WP2.1 will be used jointly with a propagation model to obtain jet installation noise radiation in the far field.

WP3 – Total jet noise prediction and validation

WP3.1: Complete installed jet noise model [M0+36 - M0+42]
A complete model will be assembled to predict the total installed jet noise, with direct jet mixing noise radiation and jet installation noise.

WP3.2: Validation of prediction method against experimental measurements [M0+39 - M0+48]
The complete model will be assessed by comparing noise predictions, possibly both in near field and in far field, with the noise experimental database generated in WP1.1 and WP2.1.

3. Major deliverables/ Milestones and schedule (estimate)

		Year 1				Year 2				Year 3				Year 4			
	Task	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16
WP1	**Jet Mixing Noise modelling**																
WP1.1	Mixing noise source eduction from experiments	X	X	X	X	X	X										
WP1.2	Mixing noise source and propagation modelling					X	X	X	X	X	X	X	X				
WP2	**Jet Installation Noise modelling**																
WP2.1	Installation noise source eduction from experiments	X	X	X	X	X	X	X	X								
WP2.2	Installation noise source and propagation modelling							X	X	X	X	X	X				
WP3	**Total jet noise prediction and validation**																
WP3.1	Complete installed jet noise prediction model													X	X		
WP3.2	Validation of prediction method against exp. measurements														X	X	X

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D1.1	Mixing noise source eduction – First year report	Report	M0+12
D1.2	Mixing noise source and propagation model – Final report	Report & measurements	M0+36
D2.1	Installation noise source eduction – second year report	Report	M0+24

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D2.2	Installation noise source and propagation model – Final report	Report & measurements	M0+36
D3.1	Complete noise prediction model	Tool	M0+42
D3.2	Complete noise prediction model validation dossier	Report	M0+46
D3.3	Final Project Report	Report	M0+48

Milestones			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Review of detailed work plan for all tasks & input delivery from Topic manager	Meeting	M0+3
M2	Project closure meeting	Meeting	M0+48

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

Demonstrated capabilities in:

- Advanced experimental capability allowing to capture the turbulence dynamics in a turbulent jet for the frequency range of interest (for instance, time-resolved PIV) in a well-controlled aeroacoustic environment. An anechoic jet noise lab should be validated and operational.
- Capability to build analytical and semi-empirical models for jet noise and jet near-field pressure fluctuations. Background knowledge on subsonic jet near-field pressure characteristics is strongly desired.
- Capability to perform flow turbulence and aeroacoustic physical analysis.

The experimental data and the models shall be made available to the topic manager during the whole duration of CS2 (LPA) project since it shall be used to predict installed jet noise of UHBR demonstrators.

Select the valid option:
(x) An Implementation agreement will be proposed to manage the IPR and the relation between the Topic manager and the Applicant(s).
( ) An Accession to the Consortium Agreement of the LPA IADP will be proposed to manage the IPR and the relation between the Topic manager and the Applicant(s).

II. Test Cell Control System for NPE Demonstrator

Type of action (RIA or IA)	IA		
Programme Area	LPA		
Joint Technical Programme (JTP) Ref.	WP 1.1.10		
Indicative Funding Topic Value (in k€)	750		
Topic Leader	Safran	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	46	**Indicative Start Date**[2]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-LPA-01-30	**Test Cell Control System for NPE Demonstrator**
Short description	
The purpose is to develop an innovative test cell control system coupling real time models for main engines and hardware (Auxiliary Power Units, Starter generator, Generator, etc.). The objective is to demonstrate the ability of a new optimised Non Propulsive Energy (NPE) system to meet aircraft needs depending on Main Engine status and operating point. This system should be compatible with an existing APU test cell.	

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

1. Background

This topic is linked with the activities of WP1.1.10-Non Propulsive Energy of platform 1 of IADP Large Passenger Aircraft (LPA). This work package addresses an activity dedicated to the Non Propulsive Energy (NPE) generation for new engines architectures; in order to identify the most relevant solution for NPE approach for the next generation of engines and aircrafts.

The perimeter of NPE activities covers 'classical approaches' (i.e. power off-takes on main engines) and other approaches dealing with the ratio propulsive/non propulsive power needs at aircraft level. It is believed that the de-correlation of propulsive and non-propulsive energy is considered as an important contributor to further increase of the overall aircraft energy efficiency and of the competitiveness. Taking this approach properly into account in the future engine design (lay-out, sizing and required modes of operation), the ambition is to gain the additional percentages of fuel burn for either CROR or UHPE concepts.

The Work Breakdown Structure of WP1.1.10 is presented in Figure 1:

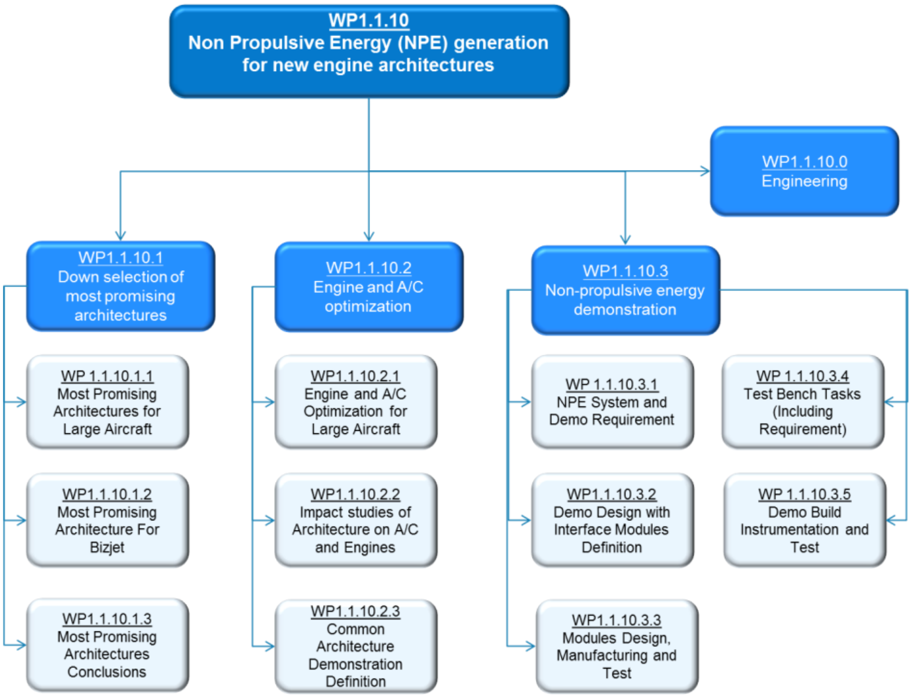


Figure 1 - Work Breakdown Structure of WP1.1.10

The studies carried out since the beginning of the project in WP1.1.10.1 & WP1.1.10.2 have shown that in some situations, the power sharing between the main engines and the APU can be of interest.
The purpose of the WP1.1.10.3 Non Propulsive Energy Demonstration is to demonstrate that the APU can withstand the new level of requirements needed (APU will not be considered as an auxiliary power source) in such systems in terms, for example, of reliability, availability, restart capability, … . It will also demonstrate a first set of power management/dispatch rules taking into account the aircraft needs of Non Propulsive Energy.

In that frame, Safran Power Units will be responsible for the design and manufacturing of a gas turbine

that will be a key element of future non propulsive energy generation systems.
In order to demonstrate that this gas turbine can withstand the requirements associated with its new functions, Safran Power Units will implement new set of capabilities onto the already developed test bench to study innovative power sharing strategies in a wider perimeter that will include both the main engines (simulated) and the APU. This new test cell will be able to operate on a real time basis real gas turbines (APU) and simulated ones (Main engines) and manage all the data transmission in between all the systems.

More precisely, the test cell and its systems should be able to:

- Read aircraft power needs from a file. These power needs will be described in terms of thrust, mechanical/electrical power and pneumatical power requirements. This input will be given by the aircraft manufacturers working in the work package.
- From this file, analyze the power needs through a power management / power dispatch control unit. This unit will be able, following power management strategies currently under study in the workpackage, to dispatch the power and thus send power requirements to the sources of the system: The Main Engines (Real Time Models) and the APU (Real gas turbine + electrical machines, Power electronics, Bleed port, …).
- Run real time model of main engines. These models will be given by Safran Aircraft Engines. They will exchange key parameters with the power management / power dispatch unit. This system that sends the power requests (thrust/mechanical/pneumatical) will take into account the main engines and APU status to adjust the requirements following specific laws.
- Drive a real APU that will produce mechanical/electrical power and pneumatical power. In order to do that the test cell will drive real electrical loads and a pneumatical network representative of an aircraft one. In order to do so, the test cell will implement innovative instrumentation and acquisition systems for the APU in order to send data the power management / power dispatch systems. This may include innovative autonomous sensors, wireless data transmission, torque measurement, vibrations & temperature innovative sensors, …
- Display panels will be implemented to display the main engine parameters, the APU parameters, …

The full system is described in the below figure 2:

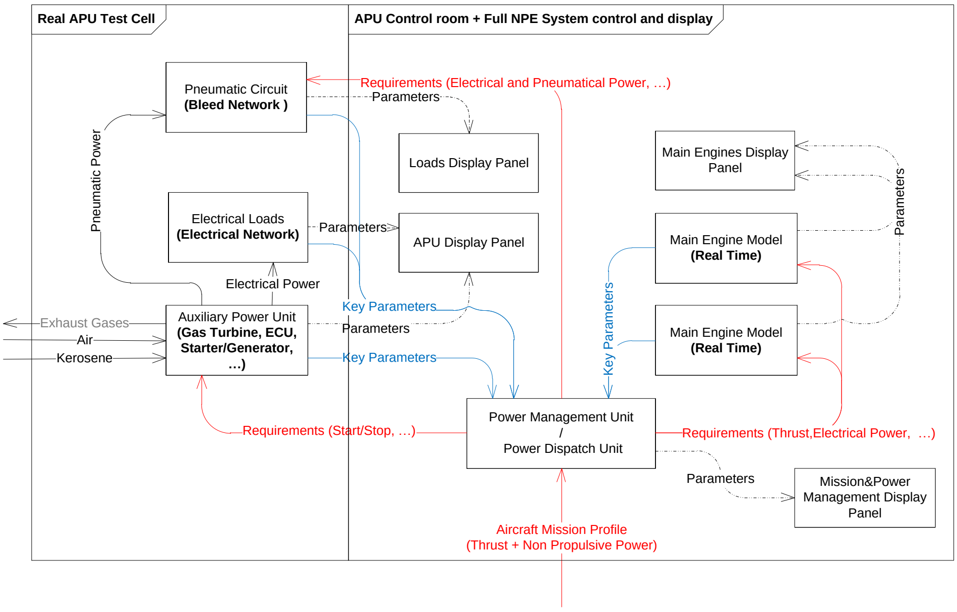


Figure 2 – Schematic of the NPE Power Sharing architecture

As presented on the schematic, the heart of the system is the Power Management / Power Dispatch unit which represents the aim of the topic. It will drive on one side 'real hardware' (Full APU system) and on the other side real time model of main engines representative of the Aircraft. By receiving parameters from these sources and following specific rules it will adjust the way the power is dispatched on the sources.
The candidate will be responsible for the prototype software architecture and will contribute with SAFRAN Power Units to implement the various strategies inside the real time software architecture developed by the candidate.

2. Scope of work

The objective is to demonstrate the ability of a new optimised NPE system to answer aircraft needs depending on Main Engine Status and operating point. This system should be compatible with an existing APU test cell.
Inside this work package, the candidate will have to propose innovative solutions on the following areas:

- Application tools for real time models architecture including a "friendly" interface and easily programmable
- Protocole exchange architectures between the different systems (Main Engine data, APU data, power management orders, …) compliant with EMI limitations
- Optimised NPE Instrumentation providing status parameters needed for Power Sharing algorithms: We are speaking about parameters linked with gas turbines like the torque on the main shaft, surge margin, temperatures, vibrations… all parameters needed to optimize the power dispatch in between the sources. Any innovative sensors, … are welcomed to improve accuracy of measurement.
- Innovative Data Acquisition System compliant with real time processes able to monitor the complete system (wireless transmission systems)

As part of WP 1.1.10.3, the applicant(s) will firstly analyse with the topic manager and the other contributing parties to the WP the high level specifications issued in WP1.1.10 and will perform feasibility study (software for real time model, software to exchange data with the ECU of the APU, …). The best technical solution will be selected. Thanks to this work, detailed specifications will be proposed by the candidate, discussed and agreed with the topic manager and the other contributing parties.
The candidate will implement the following milestones during the development:

- Preliminary design for review
- Critical Design for review
- Detailed design for review

The candidate will be then in charge of the study and the manufacturing of the simulation bay (hardware + software). The acceptance tests will be done in several steps where the candidate will lead the complete commissioning:

1) Isolated Acceptance Test (simulation bay disconnected from the NPE)
2) Integrated Acceptance Test (simulation bay connected the NPE)

In the meantime, the candidate will then have to provide:

- All definition files of the hardware
- All documentation (User manual, maintenance manual)
- All software files (open source)

Following the commissioning, SAFRAN Power Units will operate the NPE System in one of its test cell. The candidate will support SAFRAN Power Units during 6 months after simulation bay commissioning.

An Implementation agreement will be proposed to manage the IPR and the relation between the Topic manager and the Applicant(s).

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
E1	Analysis of High Level Specifications	R	T0+1
E2	Selection of technical solution	R	T0+6
E3	Preliminary Design Review	RM	T0+12
E4	Critical Design Review	RM	T0+20
E5	Detailed Design Review	RM	T0+24
E6	Isolated Acceptance Test	R	T0+36
E7	Hardware + documentation delivery	D	T0+38
E8	Integrated Acceptance Test	R	T0+40
E9	Support to SAFRAN Power Units		T0+46

*Types: R=Report, D=Data, HW=Hardware

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

Expertise and skills

- Project management
- Design of electrical architectures: Electrical machines, power electronics,
- Aircraft electrical network.
- Aircraft network protocole communications
- Gas turbine performances model
- Automatism, PLC technology
- Real time software architectures
- Data Acquisition System skills compatible with innovative sensors
- Innovative Engine sensors including signal treatment modules
- Quality manual to ensure quality of design, materials, manufacturing, instrumentation, test, conditioning and shipping of hardware
- Risk Analysis, Failure Mode and Effect Analysis
- CE, ATEX requirements

Capabilities and track record

- Company certified for Quality regulations (ISO 9001, ISO 14001) and for Design of engine subsystems or modules (CSAPU, Part 21, Part 145)

Competences to deal with risks associated to the action

- Background in Research and Technology for aeronautics especially power electronics and aircraft networks
- Background in real time software demonstrated solutions
- Project Management capability for 0,5 to 3-10M€ project
- Quality Management capability for 0,5 to 3M€ project

Expertise

- Available in the internal audit team
- Resources in house for design, manufacturing, material, instrumentation, tests

III. Representative HLFC Leading Edge structure – Torsion and Bending Stiffness Test

Type of action (RIA or IA)	IA		
Programme Area	LPA		
Joint Technical Programme (JTP) Ref.	WP1.4 Hybrid Laminar Flow Control large scale demonstration		
Indicative Funding Topic Value (in k€)	500		
Topic Leader	Aernnova	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	18	**Indicative Start Date**[3]	Q1 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CfP06-LPA-01-31	**Representative HLFC Leading Edge structure - Torsion and Bending Stiffness Test**
Short description	
The main objectives for this topic for proposal are: • To demonstrate the torsional and bending stiffness of the HLFC Leading Edge configurations by experimental testing. • To develop a test monitoring system based on novel technologies for specimen control during torsion and bending tests.	

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

1. Background

The tendency of aeronautical industry speeds up toward laminar-flow technology or active hybrid laminar flow control (HLFC), where suction of small amount of air throughout aircraft surfaces is implemented. This technique has the potential for considerable drag reduction and consequently for reducing fuel consumption. It is expected that HLFC technique can reduce the fuel consumed by 30 per cent of the current consumption for transport aircraft.

The applicant will deal with the experimental testing of a prototype HLFC system. The approximate dimensions of the specimen are 2,5m span by 0,5m chord and 0,35m height. There is a need for a dummy structure to introduce the test loading to close the L/E torsion box and the representative stiffness of the main torsion box of the stabilizer. The design introduces an advanced HLFC concept, incorporating a titanium cover to a composite Leading edge.

Following Figure 1 and Figure 2 below illustrates the area of interest and HLFC LE concept.

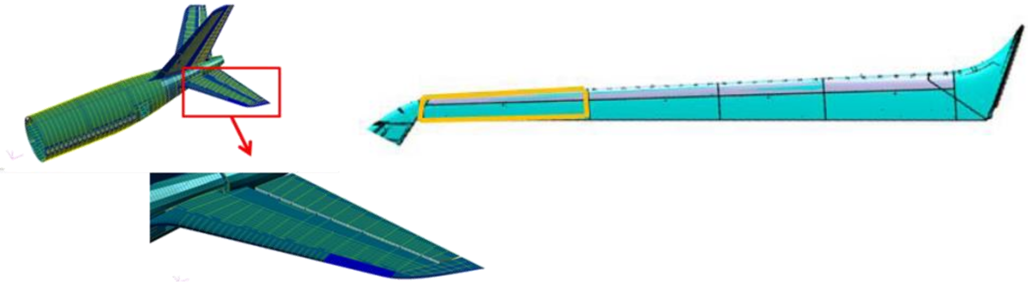


Figure 1. Area of interest. Segment 4 at HTP Leading Edge

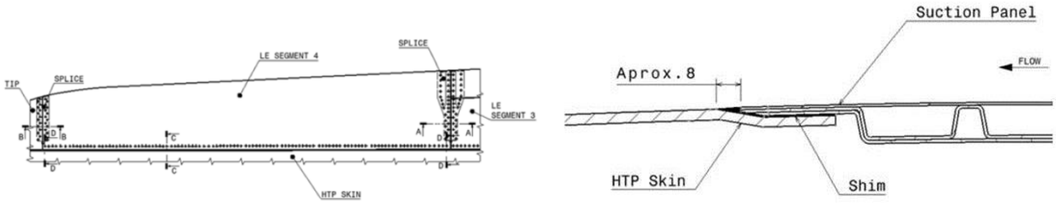


Figure 2. HTP Segment 4 Interfaces and detailed section of Leading Edge – HTP interface

Following Figure 3 below illustrates the HLFC prototype specimen under study.

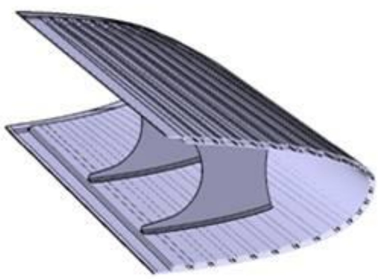


Figure 3. HLFC testing prototype

The torsional and bending stiffness of the new concept must be obtained by analytical and experimental testing to perform correlations. Structural testing procedure will focus on new monitoring and load application technologies.

The topic is broken down into several activities:
- Specimen set up definition for testing.
- Static (torsion & bending) experimental structural testing for the HLFC Leading Edge configuration using new technologies.
- Final report.

The test specimen will be provided by the topic manager.

2. Scope of work

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T0	Global test plan document issue	T0+3
T1	Innovative Testing methodology for improved load application and acquisition.	T0+12
T2	Torsion + bending test and characterisation	T0+16
T3	Test results and final deliverable	T0+18

T0 - Global Test Plan document.
The applicant should develop a test plan to obtain the torsion and bending stiffness. The Topic Manager (TP) will support this activity to the applicant.

T1 - Innovative Testing methodology for improved load application and acquisition.
Focusing on the scope of improving load application flexibility in the design and structural tests performance and in the results accuracy as well, new capabilities to apply flexion or torsion loading in the specimen are required for uniform load application over the surface of the test specimen.
The applicant should propose the use of an innovative monitoring system for the qualitative and quantitative assessment of stress-strain events during structural testing such as overloads, defects appearance or even defect growth. The objective of this monitoring system should be to provide means to ensure an efficient, high quality testing of integrated demonstrators as well as to improve the detection and quantification of localized stress which will help to reduce the product development time (Non recurrent cost), risk and cost. The objective is to develop, qualify and apply innovative test and measurement technologies for efficient, high quality testing of integrated demonstrators. This way the results of the project will also create new levels of adaptability and customization of the test configurations to allow responsiveness to late maturity of novel or disruptive designs.
The topic manager proposes the use of a combination **of novel SHM** (Structural Health Monitoring) sensors in order to qualitative and quantitative assessment of stress-strain during structural testing. Additionally the use of **non-contact systems** would be also interested for hot-spots identification.
The development of an advanced monitoring system for application to real aeronautical components will contribute to reduced lead time (and cost) for component validation, leading to earlier entry into service, reduced number of individual tests (leaner test pyramid) and improved validation methodology

to deliver greater, integrated testing of the product and provision of high-quality information for operational aspects (prognostics of structural integrity, condition based maintenance, product lifecycle) that could not be obtained by conventional testing maximizing in-service efficiency.

T2 – Torsion + Bending test and characterisation.

The Torsion and Bending experimental tests are carried out under quasi-static loading conditions.

Tests results shall provide the torsion and bending stiffness of the new HLFC Leading Edge concept in order to obtain a comparison with current design. Dummy structure with representative stiffness of the main torsion box of the stabilizer design and manufacturing is under the responsibility of the applicant. Conditioning of the test specimen prior to test and specific control of environmental parameters during test are not required (ambient temperature and humidity).

Based on previous T1 results obtained, selected load application and monitoring technologies would be implemented for testing methodology. The applicant should design and prepare the experimental test setup, including the boundary conditions, actuation systems, sensors installation, instrumentation and positioning, etc.

The design process of the test rig for a complex test like these must take into account different aspects:

- Rigidity of the test rig.
- Specimen-rig joining elements.
- Load application systems and devices.
- Test rig assembly and specimen to rig assembly.
- Verifications required such as: specimen positioning, load application direction, security measurements…
- Specimen required instrumentation.

Due to stiffness and geometry complexities, test rig shall be specifically designed to match the test boundary conditions and requirements using advanced design tools such as FEM and 3D modelling. FEM guarantees that the test rig and load application elements are going to support all the test loads without failure. Load lines are a critical parameter for these structural tests. Load lines shall be assured.

Test rig assembly and specimen installation must be performed **with strict tolerances** (TP will provide these tolerances). Measurement records and verifications registries must be accomplished to be sure that the loads are applied in the way they have been planned. The applicant shall execute the defined tests according to Test plan. Innovative sensors and systems shall be used to check and monitor the structural behaviour of the specimen during the test. Different NDT inspections may be needed to check their integrity.

T3 - Test results and final deliverable.

Final deliverables will consist of:

- Test results report.
- Comparison between the tests results and the predictions and correlation.

The Applicant(s) will interact with the Topic Manager during the analytical comparison phase, providing experimental test results in the best format for the correlation prior setting up conclusions.

Topic manager will provide information (design documentation, general requirements, specifications…) for Test Plan issue and will prepare models for later comparison, and also will supply the specimen to be tested.

The aplicant will lead and manage all the activities included in this document. Selected applicant will be the responsible for the test rig design, test rig elements manufacturing, test rig assembly at its facilities, required tests execution and test results delivery to the TP. All of these activities will be always performed under the supervision of the Topic Manager.

The Topic manager and the Applicant will closely work together all along the various phases:
- Test Plan Issue.
- Conceptual preliminary design of the test rig (PDR)
- End of the design phase (CDR)
- Test readiness (TRR)
- Structural Test campaign execution and results acceptance
- Test Completion Review

The Applicant(s) will describe and propose in their proposal the most suitable and innovative test rig design for performing the required structural tests and generate the required documentation.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D01	Test plan definition to be approved by Topic Manager.	R	T0+M3
D02	Procedure for innovative test monitoring, load application and on-line detection of defects.	R	M12
D03	Torsion + Bending test results to be approved by Topic Manager.	R	M18

*Types: R=Report, D=Data, HW=Hardware

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M01	Test plan approval	R	T0+M3
M02	Torsion + Bending test results review	R	M18

*Types: R=Report, D=Data, HW=Hardware

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

(M) - Mandatory; (A) - Appreciated

- The applicants should have a strong knowledge and experience in mechanics, characterization of composite materials and structural tests. (M).
- It is required that the Test lab had developed a Quality System to assure the Quality of all Products and Services performed by the Test Lab for its Customers. Quality System International Standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004). (M).
- Participation in international technological programs cooperating with reference aeronautical companies. (M).
- Competence in management of complex research and technological programs including test execution developments.(A).
- The test must show high level of expertise and show a quality guaranteed management and testing process. Additionally different equipment is needed in all of the tests and the test lab must be expert in different fields such as structure tests, advanced instrumentation and monitoring, advanced NDT techniques…

  Specifically, the applicant must have:
  - Design and Analysis tools of the aeronautical industry (i.e. CATIA v5 R21).
  - Testing equipment suitable for torsion and bending.
  - Tools and methods for destructive and non-destructive inspection.
  - Tools and methods for **in-situ contact-less** multi-axial strain measurement, displacements, digital image correlation, tension fields, material defects… for checking test behaviour.
  - Experience in working with geometrical verification means as laser tracker.
  - Experience on technologies for reduction testing time and costs.
  - Laboratory flexibility in the design and the performance of structures tests.
  - Experience in innovative SHM sensors and NDT techniques.

IV. Insect contamination investigations and mitigation

Type of action (RIA or IA)	IA		
Programme Area	LPA Platform 1		
Joint Technical Programme (JTP) Ref.	WP1.4 Hybrid Laminar Flow Control Large Scale Demonstrator		
Indicative Funding Topic Value (in k€)	1500		
Topic Leader	Airbus	Type of Agreement	Implementation Agreement
Duration of the action (in Months)	36	Indicative Start Date[4]	Q1 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CfP06-LPA-01-32	Insect contamination investigations and mitigation
Short description	
The aim of the project is to experimentally evaluate long-term durable coatings mainly suitable for micro-perforated hybrid laminar flow surfaces concerning their behaviour against insect contamination occurring during flight. In the first phase hydrophobic or super-hydrophobic surfaces will be developed and durability tests with regard to rain and sand erosion resistance, resistance to QUV and to common aircraft liquids will be performed. In a second phase the insect impact behaviour of newly developed HLFC surfaces and reference surfaces will be tested under simulated environmental conditions (wind, rain, ice). In a third phase the most promising HLFC surfaces shall be performed be tested under realistic representative environment to obtain both, realistic insect contamination statistics and statistically relevant assessments of insect impacts on the improved micro-perforated HLFC surfaces in comparison to reference surfaces.	

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

1. Background

Today's aircraft industry is researching a number of drag reduction technologies. Approaches to achieve drag reduction are enabling natural laminar flow (NLF) by smooth surfaces or hybrid laminar flow (HLFC) by micro-perforated metallic foils. Major problem for any operational application of laminar flow is the contamination of the air foil leading edge with insect debris. This debris acts as 3D boundary layer disturbance when reaching a critical height and can cause severe loss of laminarity by creating turbulent wedges just near to the leading edge. In the case of micro-perforated foils impacting insects additionally could clog bore holes and impede air suction effect. Therefore, reducing insect contamination on surfaces would be of high importance for realizing laminar flow conditions on leading edges. Surfaces or coatings fully preventing insect contamination would be the ultimate goal, but their development seems non-realistic in mid-term future.

In recent years a lot of investigations concerning influence of surface properties (surface energy and roughness) on insect contamination and cleaning behaviour were published. They demonstrate that both, chemistry (chemical composition) and surface structuring, determine this behaviour [1–4].

As a result two general concepts can be deduced: The concept of super-hydrophobic surfaces with a defined texture and the concept of smooth, hydrophobic surfaces. Super-hydrophobic surfaces are characterized by water contact angles around 150°, which are obtained by defined nano- and micro-structuring in combination with a hydrophobic coating. Such surfaces demonstrated in lab tests a much lower amount of debris after insect impact than standard surfaces. On the other hand the strength of adhesion of these residues, which remained on the surface, was very strong.

Smooth hydrophobic surfaces are characterized by water contact angles around 100°-120° and a low roughness (Ra < 0,02µm). After impacting of insects the amount of debris might only be slightly reduced, but in contrast to standard aircraft surfaces the removability of the residues was much easier. Such surfaces with self-cleaning properties or easy-to-clean properties enable an easy removal or wash out of contaminants due to a low bonding of contaminants to the surface. The removal is supported either only by means of environmental conditions (air stream, rain) or by means of a cleaning step or cleaning device.

In all publications related to anti-contamination or easy-to-clean surfaces the durability of surface functionality is seen as most challenging and still not solved yet. Most critical operational conditions are UV load, sand and rain erosion and load with aircraft fluids like hydraulic fluid [3].

Furthermore test strategies were developed for determination of insect contamination [1, 4]. When insects impact the leading edge, they burst and the insect fluid (hemolymph comes out) and bonds to the surface. This happens during take-off, climbing and landing of aircraft. For determination of initial impact and bonding of insects (corresponding to contamination behaviour) the amount of debris has to be determined. The removal of debris could occur actively on ground by cleaning processes or during flight (passively by airflow or actively by a cleaning device). Here the strength of adhesion determines the ease of removal. Under lab conditions the easy-to-clean behaviour can be determined by different methods depending on the applied cleaning procedure. For example: a wiping test simulates the manual cleaning on ground, a test in a climate chamber or channel applying rain and wind simulates environmental conditions.

Finally, flight tests to assess properly the insect accretion denial capability under realistic conditions are necessary for the next development step. In recent publications it was claimed, that correlations between bench top tests, wind channel and flight test are difficult to find proving that flight tests are absolutely necessary. There are some experiences available in the performance of such tests [1, 2, 3, 5]. Test samples and reference samples were applied on wing leading edges. A minimum amount of impacts on reference panel is necessary for assessment of insect mitigation on test samples. The installation of a camera is beneficial for capture of impacts. Due to the coincidental occurrence and impact of insects and to achieve statistically relevant results a series of flight tests is necessary, which are very costly and elaborate.

For some years, Airbus and its partners have been involved in some National (LUFO V) and European Research projects (Clean Sky – SFWA WP 1.3) dedicated to the development and assessment of functional coatings for aerodynamic efficiency. However, all activities and developed coatings were mainly focussed for the application an natural laminar flow leading edges but not on hybrid laminar flow one with micro-perforated surfaces. Furthermore, the durability of surface functionality often couldn't be demonstrated sufficiently.

The aim of the new project proposal within Clean Sky 2 is to continue developing hydrophobic or super-hydrophobic coatings with lower contamination or lower adhesion strength of insect bugs by improving their functional durability in terms of UV load, sand/rain erosion resistance (as a main driver) and load with aircraft fluids. In this regard the development shall mainly be focussed on coatings which can also be transferred from natural laminar flow (NLF) surfaces to micro-perforated ones typically used for hybrid laminar flow (HLFC) applications. The improved functional durability shall be demonstrated during simulated environmental (lab, rain/sand erosion facility, wind/ice channel).

The insect contamination and cleaning behaviour of the coated surfaces shall be demonstrated both, during simulated environmental (lab, wind/ice channel) and during realistic, representative environment (e.g. flying test bed). Test configurations and measures for assessment of results shall be further developed and defined to find correlations between simulated environments and realistic/representative ones. As a result of these correlations quantitative requirements on anti-contamination/easy-to-clean coatings, i.e. relevant bench top tests and conditions for passing or non-passing of coatings shall be deduced.

Outcome:

- Development of durable coatings or surfaces suitable for the application on micro-perforated HLFC leading edges (TRL3 on technical level: "Concept & Technology feasibility demonstration")
- Assessment of anti-contamination/easy-to-clean coating concepts applied on HLFC airfoils regarding their behaviour and their capability during in-service and flight
- Correlation between simulated environmental results (lab tests, wind/ice channel test) and realistic/representative ones (e.g. flight tests) to define relevant bench top tests conditions for the assessment of anti-contamination/easy-to-clean properties simulation the reality on aircraft leading edges
- Realistic insect contamination statistics and self-cleaning effects (by wind, air stream, rain, temperature) on reference surfaces and coated ones obtained by representative tests

Lit.:

[1] M. Kok, et al., Critical Considerations in the mitigation of insect residue contamination on aircraft surfaces – A review, Progress in Aerospace Sciences (2015), http://dx.doi.org/10.1016/j.paerosci.2015.02.001i

[2] C.J. Wohl, et al., Evaluation of commercially available materials to mitigate insect residue ad- hesion on wing leading edge surfaces, Prog. Org. Coat. 76 (2013) 42–50.

[3] S. Gruenke, Anti-contamination and easy-to-clean coatings for aerodynamic efficient surfaces, Proceeding of Surfair Conference, May 2012

[4] G. Patzelt, S. Gruenke, Novel functional coatings for prevention of ice-accretion and insect-contamination - approaches, correlations and limitations, Proceeding of IntAircoat, May 2015

[5] J. C. Lin, E. A. Whalen, et al., Innovative Flow Control Concepts for Drag Reduction, Proceeding of the 54st AIAA Aerospace Sciences Meeting, January 2016, San Diego, California, USA, AIAA 2016-0864

The main tasks can be described as follows:

- Development of durable anti-contamination/easy-to-clean coatings, characterisation concerning their key properties and their functional durability (QUV resistance, rain and sand erosion resistance, resistance to common aircraft liquids)
- Manufacturing of samples for testing
- Development of test configurations in lab facilities and in wind/ice channel and performance of testing
- Planning and performance of tests under realistic/representative aircraft leading edge environment
- Analysis of results
- Correlation between simulated (lab, wind/ice channel) and realistic/representative environmental test results in terms of amount of remaining insect contamination.

2. Scope of work

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T1	Development of durable HLFC coating compositions (simulated environment - lab test, coupon level)	T0+18 months
T2	Wind/ice tunnel testing (simulated environment)	T0+24 months
T3	Realistic/representative environmental insect contamination and (self-cleaning) tests (during insect season)	T0+30 months
T4	Analysis and correlation of results	T0+36 months

Task 1

- Development of coatings for insect mitigation and characterisation concerning their key properties (adhesion, flexibility, hardness) and durability (rain and sand erosion resistance, resistance to QUV, resistance to aircraft liquids).
- Coatings shall be applicable on HLFC leading edge relevant materials like Titanium or corrosion resistant steel sheets.
- Coatings shall be applicable for micro-perforated surfaces and behaviour in bore holes shall be investigated. Pressure loss characteristics through micro-perforated surfaces defined by aerodynamic shall not be influenced by the applied coating
- Applicability for natural laminar flow surfaces shall be assessed (roughness requirement Ra<0,2µm) as second priority, due to HLFC leading edges also partly exhibiting NLF areas

Task 2

This task relates to testing of surfaces under simulated environmental conditions in wind/ice channel (rain, wind, ice) and behaviour when impacted with insects with HLFC and NLF models.

- Manufacturing of models for HLFC and NLF (prio2)
- Development of test configuration
- Performance of testing in and wind/ice channel: insect impact (selection of 2 types of flies) and self-cleaning effect

Task 3

- Tests under realistic/representative aircraft (A/C) leading edge environment conditions with HLFC and NLF (prio2) samples (max. number 3 samples for each approach and 2 references)
- Performance of realistic/representative A/C leading edge tests to have sufficient insect impacts and realistic insect statistics (e.g. by using a flying test bed and 10 flight tests minimum)
- Realistic environmental tests performed also during rain or in rain clouds to assess self-cleaning effects
- In case of selecting a flying test bed, majority of flights shall be conducted below flight level 100
- Assessment: detection of amount of debris during the realistic environmental impact phase (e.g. during flight) and after each test, counting or impacts, determination of size (area, height, volume)
- Comparison of realistic environmental test results with simulated ones determined by bench top test and wind channel test results

Task 4

All results should be evaluated.

- Post-processing of data
- Detailed analysis of results, comparison/correlation of lab tests, wind tunnel tests, realistic environmental test results

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D1	Work plan description on all tasks. (Tasks 1+4)	Document	T0+2 months
D2	Durable coatings		T0+18 months
D3	Report about coating development	Data (test report)	T0+18 months
D4	Wind/ice channel test results	Data (test report)	T0+24 months
D5	Realistic environmental test results	Data (test report)	T0+30 months
D6	Final Report	Full technical report, Data	T0+36 months

Milestones			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M1	Work plan agreed (D1)	Review	T0+2 months
M2	First Coatings for wind channel testing available	Review	T0+18 months
M3	Wind/ice tunnel tests completed (D5)	Review	T0+24 months
M4	Time plan and sample configuration for realistic environmental tests prepared	Review	T0+24 months
M5	Coatings/surfaces for realistic environmental test available	Review	T0+24 months
M6	Realistic environmental tests completed	Review	T0+30 months

Milestones			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M7	Final report (D1-D6)	Report	T0+36 months

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

This package of work will require expertise in field of:

- Experimental coating development and testing (coupon level)
- Wind/ice channel facility
- Availability of test equipment to investigate and assess insect impacts and coatings under realistic/representative A/C leading edge environment
- Skills and instruments for measurement and characterisation of insect debris under simulated environment and under realistic/representative one

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:

- development of coatings
- expertise in performance of wind/ice channel test
- expertise in performance tests under realistic/representative aircraft leading edge environment

An Implementation agreement will be proposed to manage the IPR and the relation between the Topic manager and the Applicant(s).

V. Multi-physics modelling of elementary physical phenomena applied to an innovative high temperature engine valve

Type of action (RIA or IA)	IA		
Programme Area [SPD]	LPA		
(CS2 JTP 2015) WP Ref.	WP 1.5		
Indicative Funding Topic Value (in k€)	1100		
Topic Leader	Liebherr	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	48	**Indicative Start Date**[5]	Q1 2018

Topic Identification code	**Topic Title**
JTI-CS2-2017-CfP06-LPA-01-33	**Multi-physics modelling of elementary physical phenomena applied to an innovative high temperature engine valve**
Short description	
The design of valve, especially in engine environment (high temperature, high pressure, vibrations), requires high fidelity physical models to ensure performances and reduce risks of integration. The project proposal covers advances on multi-physics modelling of valve taking into account high temperature environment: effects on spring stiffness, on mechanical frictions for example. The physical models will be validated using test rigs results.	

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

1. Background

In the frame of LPA WP1.5.3, a pneumatic regulating bleed air valve is expected to be integrated in an innovative lift recovery system. This topic shall enable a predictive assessement of the functionality, performance and controlability of pneumatic valves by defining predictive behaviour of elementary phenomena.
The Topic Manager is designing pneumatic valves for differents aircraft air systems. The design and integration of such equipment are becoming a challenge for aggressive environment encountered near the aircraft engine: high temperature, high pressure and high level of vibration for instance. The design optimization of pneumatic valve requires to improve our knowledge on physical implications of this challenging environment.
Three physical domains are involved in this problematic: mechanics, fluid mechanics and thermal. The topic objectives are focused on the predictive modelling of elementary physical phenomena encountered in pneumatic valve in engine environment. The modelling activity will be fed by theoritical, numerical and experimental studies to achieve the required level of accuracy and confidence for the Topic Manager applications. The models resulting from this topic will be integrated in the physical modeling framework developed by the Topic Manager and based on the multi-physics modeling language MODELICA.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
1	Mechanical Models	
1.1	Friction Coefficients Database Generation	T0+18
1.2	Piston Sealing Ring Friction Experimental Study	T0+36
1.3	Piston Sealing Ring Friction Numerical Study	T0+36
1.4	Butterfly Sealing Ring Friction Experimental Study	T0+48
1.5	Diaphragm Mechanical Study	T0+48
2	Fluid Models	
2.1	Butterfly Aerodynamic Torque Models	T0+48

Friction is a common mechanical non-linear effect that impact significantly the overall behavior and performance of a valve. For pneumatic valves regulating into the same duct line, it could lead for example to fully pneumatic oscillations that interfere with expected behavior.

Task 1.1 - Friction Coefficients Database Generation

The Topic Manager uses several material to design valves for Engine environment. The first study is dedicated to the experimental characterization of the friction coefficients between material. The Topic manager has identified about 10 materials couples to charaterize. To cover the whole operational domain of such friction coefficient, the expected experimental tests bench should be able to produce results for :

- Operating temperature in the range of -50°C to 700°C,

- Operating contact pressure in the range of 0.1 MPa to 1 GPa

The wearing effect on the friction coefficient may also be adressed to define begin-of-life and end-of-life properties. This friction coefficient database will be then an input for the friction mechanism studies.

Task 1.2 - Piston Sealing Ring Friction Experimental Study

In pneumatic valves, the butterfly valve is actuated by a piston for engine severe environnement. The piston mouvement is linked to the pressures applied on each sides. To enable the piston to move and preserving the pressure on each side, it is required to use a sealing element that is compliant with these two functions : the sealing ring. The design of such sealing ring ensure the valve performance.
The proposed study is to analyse and model the friction effort produced by the mechanism composed of :

- The piston itself,
- The piston sealing rings,
- The piston chamber.

An experimental test bench shall be used to measure such efforts generated by the piston mechanism. Analytical frictional effort models shall be produced starting from the experimental results. The Topic manager will provide the definition of the mechanism (geometry) and operating conditions.

The piston rough characteristics are :

- Piston diameter : from 6 cm to 10 cm
- Piston stroke : around 5 cm
- Piston operating pressures : up to 8 bars
- Piston operating temperature range : from -50°C to 700°C

Task 1.3 - Piston Sealing Ring Friction Numerical Study

The experimental results obtained in Task 1.1 and 1.2 will then used to build up a numerical methodology (using tools likes ABAQUS or equivalent) to predict such friction effort. This methodology will enable the Topic manager to make evolve the detailled design based numerical predictions.

The objective of this study is then to build-up a numerical methodology and to validate it using the experimental test bench results. Analytical models created from the produced data shall be delivered. The piston characteristics are presented on Task 1.2.

Task 1.4 - Butterfly Sealing Ring Friction Experimental Study

Similarly to the piston sealing ring, the butterfly sealing enable to isolate the upstream and dowstream part when the valve is closed. Starting from the full opened position, a slight part of the sealing ring is in contact with the valve body. When closing the valve, sealing surface in contact increases with a maximum contact surface for full closed position. The friction effort evolves than depending on the valve opening angle and operational conditions. The non-linearity near closing position is significant and could impact the valve performance (moving delay, instability). The proposed study is to analyse and model the friction effort produced by such mechanism composed of:

- The valve butterfly,
- The valve body,

* The valve sealing ring.

An experimental test bench shall be used to measure such friction efforts generated by the butterfly mechanism. Analytical frictional effort models shall be produced starting from the experimental results. The Topic manager will provide the definition of the mechanism (geometry) and operating conditions.

The butterfly rough characteristics are :

* Butterfly diameter : from 4 cm to 15 cm,
* Butterfly angular stroke : 0° to 90°,
* Butterfly operating pressures : up to 10 bars
* Butterfly operating temperature range : from -50°C to 700°C

Task 1.5 - Diaphragm Mechanical Study

A pneumatic valve uses pressure and pressures differences for achieving its pneumatic functions. Depending on the technology, the pressure difference could be achieved using a diaphragm. As a deformable component, the diaphragm contributes to the mechanical equilibrium and impact the pneumatic function performance.
The first challenge is to characterize the material used by the Topic manager in term of mechanical properties (structural and dynamic). The material properties shall be determined for severe engine environement such as high temperature (up to 700°C). The second challenge is to determine the effective force transmitted by the diaphragm. On a solid separator, the mechanical force is simply the product of the pressure difference by the geometrical surface. For a deformable separator, a proportion of the pressure difference is used to deform the diaphragm and is not tranmitted as a mechnical force to connected elements. The last challenge is to determine the mechanical properties of the diaphragm (stiffness, damping for instance) with respect to its geometry and materials. These two challenges are higly related to their operational environment.
The objective is to find and validate accurate models based on its definition (geometry, material). A database shall be then created to enable the prediction of membrane performance with repect to operational conditions.

The diaphragm rough characteristics are :

* Diaphragm diameter : from 2 cm to 10 cm,
* Diaphragm thickness : 0° to 90°,
* Diaphragm operating pressures : up to 5 bars
* Diaphragm operating temperature range : from -50°C to 700°C

Task 2.1 - Butterfly Aerodynamic Torque Models

A valve is composed by an actuator (to control the valve opening area) and by the pneumatic element that modify the streamflow. The aerodynamic properties of this pneumatic element (butterfly for example) are important to predict the pneumatic valve performance. For instance, the aerodynamic torque will contribute to the pneumatic actuator mechanical equilibrium, making evolve the overall valve performance. The pressure losses generated by such element is important to predict a quantitative behaviour of the valve, especially for near to close position where strong aerodynamic effects could occur.

A first challenge is to predict accuratly the aerodynamic properties for the Topic Manager‘s geometries.

The second challenge is to predict the impact of non-homogeneous flow distribution on aerodynamic properties. This last topic is critical for equipment to predict system integration impacts. The pneumatic valves are often integrated in reduced/compact volume with complex ducting. The flow distribution upstream the valve is often non-homogeneous.

The study shall be based on experimental data and produces analytical models fitted from test results. The Topic manager recommands that the exprimental test bench required for Task 1.4 is re-used to conduct the exprimental study of the butterfly aerodynamic performances.

The butterfly characteristics are the same as presented in Task 1.4. For the aerodynamic study, we can add the following operational condition :

- Mass Flow rate : up to 2 kg/s

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1.1.1	Friction Coefficient - Test Bench	HW	T0+6
ID1.1.2	Friction Coefficient - Intermediate Experimental Study Report	R	T0+12
D1.1.2	Friction Coefficient - Experimental Study Report	R	T0+18
D1.1.3	Friction Coefficient - Experimental Database	D	T0+18
D1.2.1	Piston Sealing Ring Mechanism - Test Bench	HW	T0+12
ID1.2.2	Piston Sealing Ring Mechanism - Intermediate Experimental Study Report	R	T0+18
D1.2.2	Piston Sealing Ring Mechanism - Experimental Study Report	R	T0+30
D1.2.3	Piston Sealing Ring Mechanism – Friction Effort Model Report	R	T0+36
D1.3.1	Piston Sealing Ring Mechanism - Numerical Study Report	R	T0+36
D1.4.1	Butterfly Sealing Ring Mechanism - Test Bench	HW	T0+18
ID1.4.2	Butterfly Sealing Ring Mechanism - Intermediate Experimental Study Report	R	T0+24
D1.4.2	Butterfly Sealing Ring Mechanism - Experimental Study Report	R	T0+36
D1.4.3	Butterfly Sealing Ring Mechanism – Friction Effort Model Report	R	T0+36
D1.5.1	Diaphragm Material Experimental Study	R	T0+38
D1.5.2	Diaphragm Mechanical Properties - Experimental Study	R	T0+46
D1.5.3	Diaphragm Mechanical Properties - Experimental Study	R	T0+48
D2.1.1	Butterfly Sealing Ring Aerodynamic Properties - Test Bench	HW	T0+38
D2.1.2	Butterfly Sealing Ring Aerodynamic Properties - Experimental Study Report	R	T0+48

*Types: R=Report, D-Data, HW=Hardware

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

Skills

- Mechanical Contact (Friction) applied to pneumatic products related with high temperature
    - Experimental background to set-up a friction test bench
    - Theoritical background regarding friction simulation
- Thermo-Mechanics for temperature effects on diaphragm
    - Theoretical and Numerical background to simulate such effects
- Fluid Mechanics for aerodyanmic torque study
    - Experimental backgroud to set-up an aerodynamic torque test bench

Capabilities

- Air Generation for test benches
- Temperature / Pressure environmental control

VI. 3D printing and harsh environment testing of flow control actuators at aircraft scale

Type of action (RIA or IA)	IA		
Programme Area	LPA		
Joint Technical Programme (JTP) Ref.	WP 1.5.3		
Indicative Funding Topic Value (in k€)	550		
Topic Leader	Airbus Group Innovation	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	18	**Indicative Start Date**[6]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-LPA-01-34	**3D printing and harsh environment testing of flow control actuators at aircraft scale**
Short description	
The objective is to 3D print flow control actuators at aircraft scale and to expose them to harsh environment (HE) testing. Using the outcome of the first HE tests, an optimization loop of the actuator design will be performed followed by a second HE test.	

[6] 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" (BR) and lower "Fan Pressure Ratios" (FPR). Associated with both are larger fan diameters along with larger engine nacelles, typical for "Very High Bypass Ratio" (VHBR) or UHBR engines.
With increasing nacelle size of such UHBR engines, it is more difficult to ensure sufficient clearance between the nacelle and the runway for the aircraft on ground. The close coupling requires a slat-cut-back in the region of the wing/pylon junction in order to avoid clashes of the deployed slat with the nacelle. The slat-cut-backs lead to the risk of aerodynamic flow separation and subsequent degradation of the maximum lift. The maximum lift coefficient for the landing configuration is directly related to the achievable payload or aircraft flight range.
To remedy this problem Active Flow Control (AFC) based on steady and pulsed air blowing with net mass flux (bleed air) is applied at the engine-wing junction either at wing leading edge or at the engine pylon.
Recently, 3D printing has shown considerable potential to tackle the challenge of a quite restricted installation space and geometric complexity of the pulsed jet actuators with net mass flux. This approach seems to be also favorable in the regard of future flight tests. For hardware qualification as necessary step for flight tests, actuation concepts have to prove that they withstand high temperatures of the feeding bleed air (up to 260°C) and properly work also under harsh environment conditions.
The 3D printing technique of small parts with low complexity is a well-established method and frequently applied for manufacturing. However, when using the 3D printing method for components of Titanium having larger dimensions (up to 350mm) and showing higher complexity, the process is not yet mature and the reliability of the components is not given.
Also, the 3D printing technique opens opportunities until now unknown for structural design optimization. Bionic methods for structural design could be applied for an optimization of the structure w.r.t. strength and weight.
It is also conceivable, to use a combination of different materials for the components manufacturing, ensuring however the requested reliability and performance of the actuators.
The subject of this CfP is the 3D printing of reliable and safe flow control actuators (two types) able to withstand the high temperatures (up to 260°C) and pressures (5 bar) during flight tests. The activities include also harsh environment testing of the two types of actuators (pulsed jet blowing and steady blowing) at aircraft scale and re-design activities to assure a safe operation under harsh environment conditions.

2. Scope of work

For the preparation of the flight test with active flow control, two types of actuators, namely Pulsed Jet Actuators (PJA) and Steady Blowing Actuators (SBA) have to be manufactured in Ti using 3D printing. To prove a stable and high quality printing process, three actuators have to be printed from each of the two types, allowing however for variations in the printing process to optimize the result.

The 3D printed actuators will be tested in a harsh environment (HE), representing the operating conditions of the aircraft. The test matrix is given in Table 1 and detailed information about the HE testing conditions will be delivered by the consortium.
Tests will be done with all three actuators per type to assure a sufficient high statistical validity of the test results (statistical variance). Using the HE test results, an optimized design for both types of actuators will be elaborated and implemented, to overcome potential deficiencies observed during the

first HE tests.

A second batch of optimized actuators will be printed and tested at the same HE conditions.
The number of the printed new actuators for the 2nd batch will be also three per type of actuator to assure the results of the second HE test will be relevant.
The work is grouped into the following tasks:

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T1	Adaption of the design of flow control actuators and infrastructure to 3D printing manufacturing principles.	M2
T2	3D printing of flow control components (original design)	M6
T3	Aerodynamic and harsh environment testing of flow control components.	M10
T4	Analysis of aerodynamic and harsh environment tests	M11
T5	Definition of improved design and 3D printing of improved flow control components	M15
T6	Aerodynamic and harsh environment testing of improved flow control components	M17
T7	Analysis of aerodynamic and harsh environment testing of improved flow control components	M18

Task 1: Adaption of the design of flow control actuators and infrastructure to 3D printing manufacturing principles
The applicant has to adapt the design of the flow control actuators to 3D printing manufacturing principles. The original design of the flow control actuators (PJA and SBA) will be provided by the consortium. The actuators shall be printed preferably in Ti to withstand a high temperature environment (up to 260°C).
However there is an opportunity to optimize the design of the actuators using bionic design principles, provided the requirements for performance, structural strength and functionality of the actuators are met.

Task 2: 3D printing of flow control components (original design)
A series of three actuators from of each type (PJA and SBA) shall be printed in Ti, satisfying aerodynamic requirements of the actuators (uniformity of the jet velocity in span wise direction, moderate pressure losses inside the actuators). The aerodynamic properties of the actuators are influenced by the shape accuracy and surface roughness of the printed parts. Details about the manufacturing requirements will be given by the consortium.
In case the applicant is able to prove a mix of different materials used for the manufacturing of the actuators is also feasible w.r.t. the aerodynamic, structural and thermal requirements, this option will be considered as well.
The printing process shall ensure a high consistency between the three actuators in quality and performance, which is needed to guaranty a sufficient high validity of the following aerodynamic and harsh environmental tests (statistical variance). The quality of the actuators will be proved by complying with a given surface quality and shape accuracy.

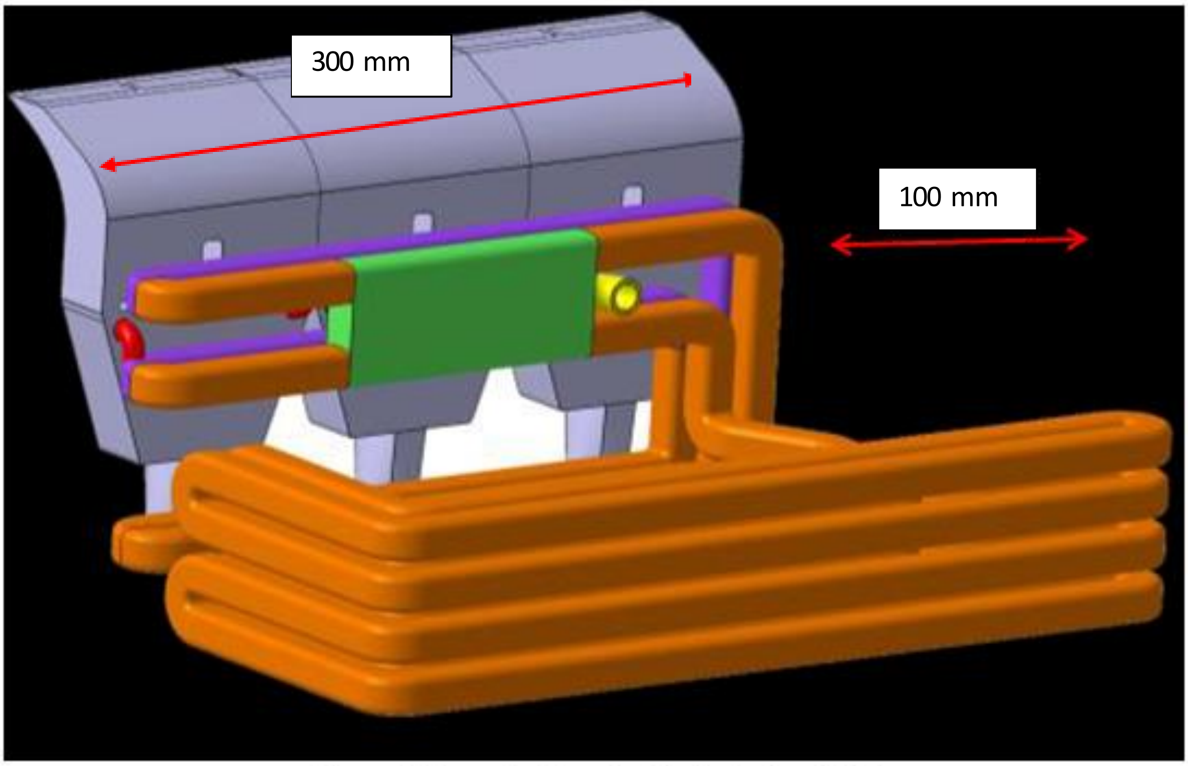


Figure 1: Example of a pulsed jet actuator (PJA)

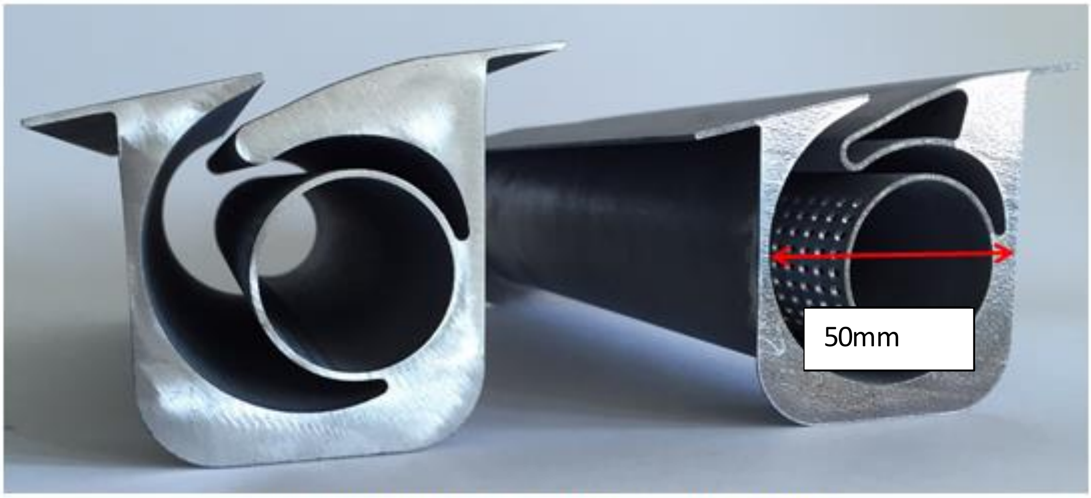


Figure 2: Example of a steady blowing actuator (SBA)

Task 3: Aerodynamic and harsh environment testing of improved flow control components
The aerodynamic testing of the 3D printed actuators will be carried out and used to evaluate the repeatability and steadiness of the printing process. The aerodynamic tests will comprise measurements of the pressure losses in the flow actuators and measurements of the jet velocities at different span wise positions of the jet exhaust (prove of jet uniformity).

The 3D printed actuators will be tested afterwards in a harsh environment, including rain, icing, sand and dust, vibrations and anti-icing fluid. Tests will be carried out partially with all three printed actuators from each type (PJA, SBA) to assess the statistical variance of the results. Details of the harsh environmental tests (e.g. temperatures, icing conditions, vibration amplitudes and frequencies etc.) will be given by the consortium.

To accelerate the total project and grant some time buffers, it could be considered to start the aerodynamic and HE tests as soon as the first type of actuators are printed, not waiting for both actuator types to be printed before starting the tests. This decision will be left to the evaluation of the applicant.

Actuators / Test	Rain	Ice	Sand & Dust	Vibrations	Anti-icing Fluid
PJA 1	X	X	X	X	X
PJA 2		X		X	
PJA 3		X		X	
SBA 1	X	X	X	X	x
SBA 2		X		X	
SBA 3		X		X	

Table 1: Harsh environment test matrix

Task 4: Analysis of aerodynamic and harsh environment tests

An analysis report of the tests will be delivered, including the detailed testing conditions and the variations of the test results between the same types of actuators.

Task 5: Definition of improved design and 3D printing of improved flow control components

Based on the HE test results and lessons learnt, a design improvement of the flow control components will be elaborated by the consortium in close cooperation with the applicant. The improved design will be implemented subsequently by the applicant aiming to overcome the shortcomings seen during the first HE test.

A 2^{nd} batch of improved actuators will be printed, comprising actuators for both PJA and SBA.

The number of printed actuators will be also three per type of actuator.

The new printed actuators shall comply as well with the given requirements for the 1^{st} batch on surface quality and shape accuracy.

Task 6: Aerodynamic and harsh environment testing of improved flow control components

Using the optimized 3D printed actuators a 2^{nd} series of aerodynamic and HE tests will be conducted using the same test conditions applied during the first tests.

Task 7: Analysis of aerodynamic and harsh environment tests of improved flow control components

An analysis report of the 2^{nd} test will be delivered, including the detailed testing conditions and, if applicable, the variations of the test results between the same actuator types. The gain of performance in aerodynamics and w.r.t the HE conditions of the new designed actuators will be analysed.

3. Major deliverables/ Milestones and schedule (estimate)

Ref. Nr.	Deliverable Title	Type	Due date
D1	Delivery of the 3D printed actuators (original design)	Hardware	M6
D2	Analysis report of the first aerodynamic and HE tests	Report	M11
D3	Delivery of the 3D printed actuators (improved design)	Hardware	M15
D4	Analysis report of the second aerodynamic and HE tests	Report	M18

Ref. Nr.	Milestone Title	Due date
M1	First aerodynamic and harsh environmental test finished (original design)	M10
M2	Decision about the design changes for the second batch of printed actuators (improved design)	M12
M3	Second aerodynamic and harsh environmental test finished (improved design)	M17

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

The applicant shall have profound knowledge in 3D printing in Ti and other materials for aircraft applications, proving a stable and repeatable printing process. The applicant must give proof of having profund knowledge of design techniques to be applied for 3D printed components, including opzimization w.r.t. strength and weight.
The applicant shall have profound knowledge in harsh environmental testing. He shall provide or have access to the corrsponding test facilities for harsh environmental tests and should have experience in conducting such tests for the aerospace industry.
aerodynamic and.

An Implementation agreement will be proposed to manage the IPR and the relation between the Topic manager and the Applicant(s).

VII. Innovative compact heat exchangers modelisation & characterization

Type of action (RIA or IA)	RIA		
Programme Area [SPD]	LPA		
(CS2 JTP 2015) WP Ref.	WP 1.6		
Indicative Funding Topic Value (in k€)	1500		
Topic Leader	Liebherr	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	48	**Indicative Start Date**[7]	Q1 2018

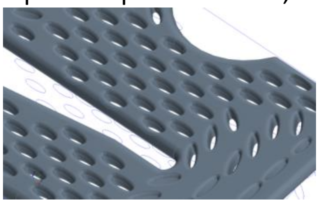
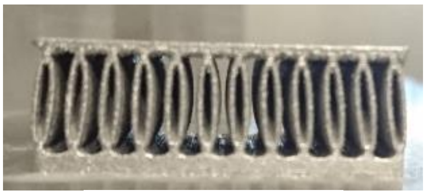
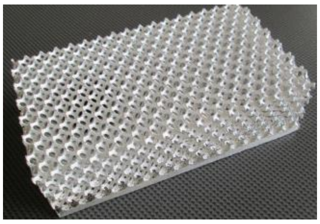
Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-LPA-01-35	**Innovative compact heat exchangers modelisation & characterization**
Short description	
The objective of this topic is to propose new fins and overall structures predictive models or laws (thermal and pressure drop) to be used for complex compact heat exchanger design including the one obtained by additive manufacturing. Characterization and experimental validation on samples will be required.	

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

1. Background

In the frame of the LPA platform 1, the Topic Manager aims to contribute to the WP 1.6 by supporting the development of a thermal management system dedicated to hybrid propulsion system. Compact air-air heat exchangers have been studied extensively over several decades by industrial and academics. Some of these works are now white paper and used daily in the conception of heat-exchanger [1][2][3]. However these designs rely on well-known and establish manufacturing process and reachable performances are known and limited. Moreover, complex shapes are not possible with such process and integration of the resulting heat exchanger can be a challenge.

With the rise of new manufacturing processes and more specifically additive manufacturing, new fin shapes[4] / structures, channels arrangements and connections can be thought for performance enhancement and complex shape realization, facilitating integration.


Swansea University Formula Student race car intercooler

The goal of this project is to focus on developing new compact air-air heat exchanger families that best address thermal fatigue, envelope optimization, pressure drop, flow distribution, and thermal performance and hence producing designs that feature high thermodynamic efficiency, including thin-walled and highly complex structures. In this frame of work, the heat exchanger shall be considered not only at a fin elementary pattern level, but also at a whole product level where fluid distribution is not homogeneous, where inlet and outlet diffusers play a major rule on heat exchanger performance.

The CHX family under study will be air-air heat-exchanger with the following main characteristics:

- Reynolds number inside the fins ranging from 400 to 10000,
- Inlet temperature ranging from -55°C up to 600°C,
- Material should be aluminum and nickel alloy,
- Size of interest for the overall fins matrix are ranging from 20 cm^3 for the low side up to 0.1 m^3 on the high end,
- Power ranging from 0.5 up to 500 kW.

[1] W.M. Kays, A.L. London, “Compact Heat Exchangers”, (Third Edition) Krieger Publishing Company, New York (1998)

[2] R.J.Manglik et A.E.Bergles, “Heat transfer and pressure drop correlations for the Rectangular ofsset strip fin compact heat exchanger”, Experimental Thermal and Fluid Science, vol. 10, pp.171-180, 1995

[3] A. Muley, J.B. Borghese, R.M. Manglik, J. Kundu, “Experimental and numerical investigation of thermal-hydraulic characteristics of a wavy-channel compact heat exchanger”, 12th International Heat Transfer Conference, Grenoble, 2002.

[4] Muley, A., “Advanced Heat Exchangers for Enhanced Air-Side Performance: A Design and Manufacturing Perspective”, an invited presentation in ARPA-E Advanced Dry Power Plant Cooling Workshop, Chicago, IL, May 12-13, 2014.

2. Scope of work

Tasks		
1	Bibliography of the recent (academic as well as industrial) research on compact air-air heat exchanger structures / fins shapes built with AM	T0+6
2	Choice(s) and optimization of heat exchanger fins / structure and numerical performance analysis	T0+24
3	Validation of performance laws by means of an experimental set-up	T0+30
4	Macro-scale modelling of the heat exchanger for thermal and fluidic optimization integrating design conclusions inherited from Task 2 Designs of a CHX based on 2 specifications	T0+40
5	Validation of the new CHX by means of an experimental set-up	T0+48

Task 1
Bibliography should focus on enhanced heat transfer techniques for CHX which provide a reduction in thermal resistance of a conventional design – with or without surface area increase (as obtained from extended / fin surfaces). Within this domain the emphasis should be put on passive enhancement like treated surfaces, rough surfaces, extended surfaces, swirl or turbulence flow devices/surfaces, …

Task 2
Based on the specification of the CHX family provided by the Topic Manager and based on the findings of task 1, one or several structures / fins based on one or a combination of EHT should be proposed such as maximazing the ratio of nusselt over pressure drop.
Overall performance (Nusselt and pressure drop laws as a function of the Reynolds number) of elementary fins shapes / structures should be assessed using advanced numerical simulations (CFD).

Task 3
Overall performance (Nusselt and pressure drop laws as a function of the Reynolds number) obtained during task 2 should be validated by the applicant(s) against test over the full range of Reynolds number.

Task 4
Based on two detailled specifications of CHX provided by the Topic Manager, two CHX using the new fins shapes / structure (task 2) should be proposed, one in Aluminum Alloy and one in Nickel alloy , and an integration to a macro-scale approach (inlet and outlet boxes included) in order to relate local fins / structure performance to global heat exchanger enhanced conception. Detailed design methodology and numerical simulation (performance and stress) are expected to be performed by the applicant(s) during this task.

Task 5
Overall performance of the two new CHX should be validated by the applicant(s) against test over the full range of operating point provided by the Topic Manager.

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	**Title - Description**	**Type***	**Due Date**
1	Bibliography Report	R	T0+6
2	Fins / Structure Design Report	R	T0+24
3	Test Campaign and Analysis at fins / elementary structure scale	R+D	T0+30
4	CHX Design Report	R	T0+40
5	Test Campaign and Analysis at CHX scale	R+D	T0+48
6	CHX + elementary fins specimen	HW	T0+48

*Types: R=Report, D-Data, HW=Hardware

Milestones (when appropriate)			
Ref. No.	**Title - Description**	**Type***	**Due Date**
1	Fins / Structure Design Intermediate Milestone	R	T0+12
2	CHX Design Intermediate Milestone	R	T0+35

*Types: R=Report, D-Data, HW=Hardware

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

Skills
- Thermodynamics applied to CHX
- CHX design
- CHX manufacturing knowledge
- Additive Manufacturing knowledge
- CFD & Finite element stress computations

Capabilities
- Computing facilities in order to be able to predicit news shapes of fins' / structure performances
- Additive Manufacturing machines to manufacture elementary heat exchanger elements and full size heat exchanger (size 400 mm*200 mm*1300 mm) with Aluminum and Nickel alloy powders
- Testing facilities in order to be able to charaterized news shapes of fins / structure with air (temperature range: -15°C/+300°C , flow range: 0.01kg/s; 0.5kg/s) and full size heat exchangers with air (temperature range: -55°C/+600°C , flow range: 0.01kg/s; 3kg/s)

5. Abbreviations

CHX	Compact Heat-Exchanger
AM	Additive Manufacturing
EHT	Enhanced Heat Transfer Techniques
ECS	Environmental Control System
CFD	Computational Fluid Dynamics

VIII. SmartContainer

Type of action (RIA or IA)	IA		
Programme Area	LPA Platform 2		
Joint Technical Programme (JTP) Ref.	WP2.1		
Indicative Funding Topic Value (in k€)	2000		
Topic Leader	Airbus	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[8]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-LPA-02-16	**SmartContainer**
Short description	
Development and manufacturing of new dimensioned intelligent lightweight aircraft cargo container (SmartContainer) for fully automatic lower deck cargo loading with minimum systems and components on the aircraft. Capabilities of SmartContainer: • communication wireless with the aircraft • self-moving or via additional drive unit(s)(inside of cargo compartment) • self-acting locking incl. monitoring • fulfilment of all smoke and fire requirements • backward compatibility • forklift interface • robustness and reliability • airworthiness • light weight • cost-efficiency	

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

1. Background

The overall objectives, linked closely to the CleanSky2 (CS2) objectives are:

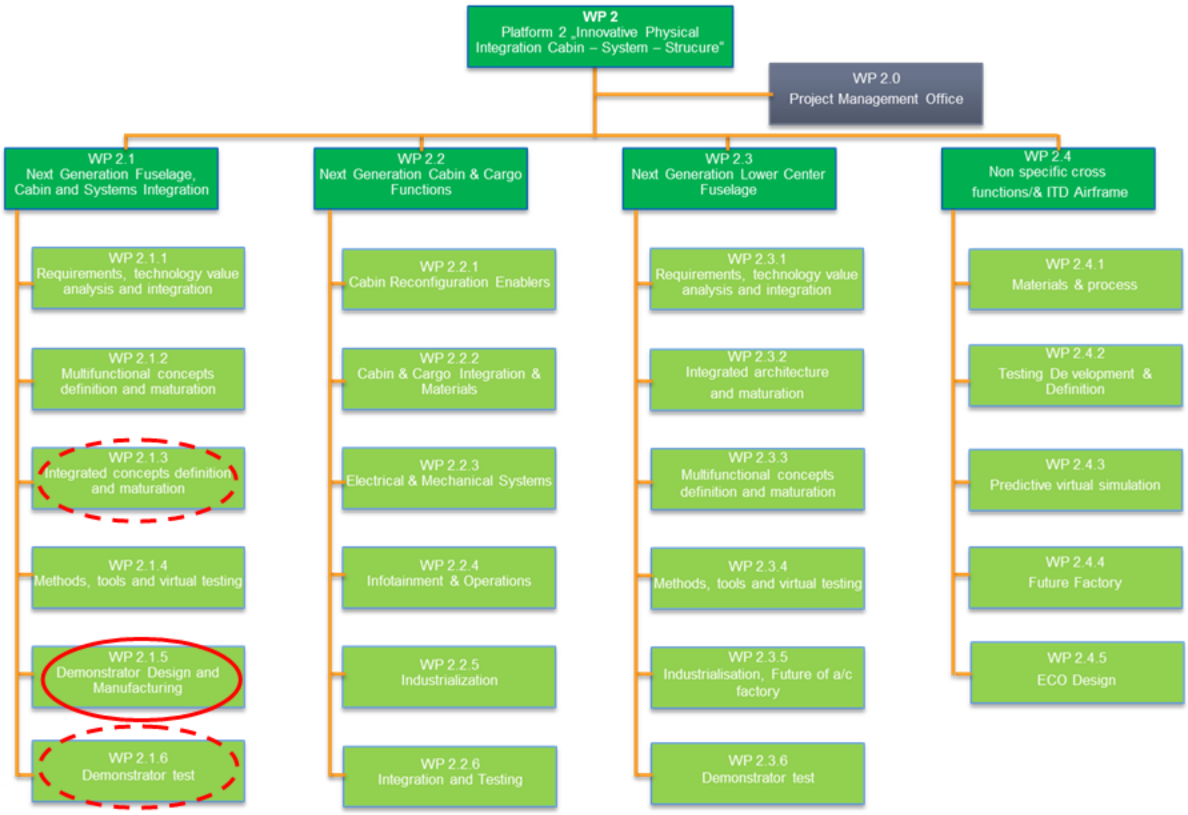
- Reduction of manufacturing time and costs
- Enable a high production rate of minimum 60 aircrafts per month
- Weight reduction
- Recurring cost reduction
- Optimization of cargo operation / handling

compared to a fully equipped current Single Aisle Aircraft fuselage as benchmark.

The approach of the Innovative Physical Integration Cabin-System-Structure Platform 2 is to provide the frame for large-scale complex demonstration at full size for validation and testing on the ground.
The target is to validate intelligent innovative solutions for lower deck cargo loading, which enable the removal of aircraft cargo relevant components and systems, to take advantage of unused or partly used cargo compartments.
The driver of this approach is to attain a significant fuel burn reduction by substantially reducing the overall A/C energy consumption, applying low weight systems and system architecture/integration and to be able to cash in weight potentials in the lower deck cargo design. This must be achieved by the development and application of Industry 4.0 opportunities such as design for manufacturing & automation, automation, sensorization, data analysis and secure data exchange to demonstrate the desired manufacturing costs effects.

Platform 2 is organized along four Work Packages, which reflect the three main demonstrators

- Multifunctional demonstrator (WP2.1)
- Cabin/ Cargo demonstrator (WP2.2)
- Lower Center Fuselage demonstrator (WP2.3)
- and the cross-functional enablers (WP2.4)

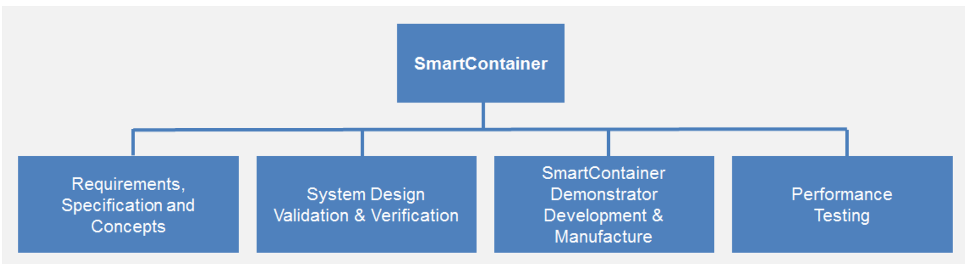


The applicant's work will be directly linked to WP2.1.5 "Demonstrator Design and Manufacturing" with smaller contributions to WP2.1.3. "Integrated Concepts Definition and Maturation" and WP2.1.6 "Demonstrator Test"

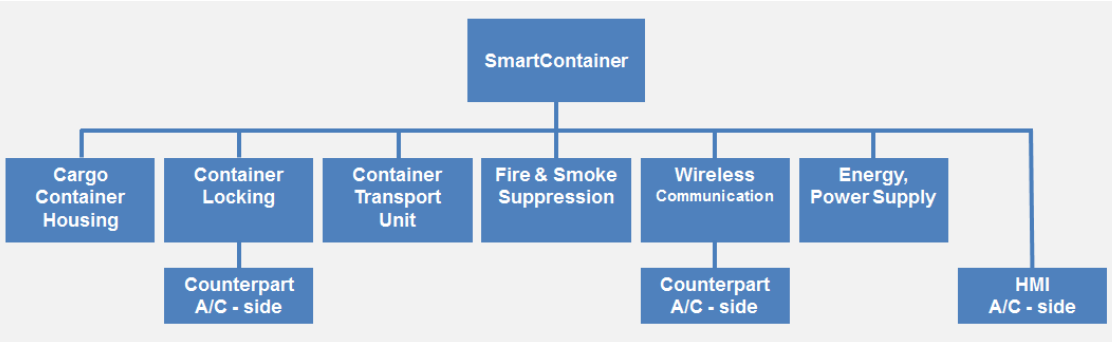
2. Scope of work

The focus within this call lies on development and manufacturing of an new dimensioned intelligent lightweight aircraft cargo container (SmartContainer) with integrated functions for restrain, transportation, fire & smoke suppression and wireless application.

a) Possible Work Breakdown Structure (WBS)



b) <u>Generic Product Breakdown Structure (PBS)</u>



c) The SmartContainer is classified as a Type 2 ULD in accordance to AS36100 and shall be designed in accordance to ISO11242, ISO21100, ISO6517 and other applicable typical ISOs for ULDs. The SmartContainer shall be designed for a payload of min. 500 kg. Smoke generated inside the SmartContainer shall not propagate into other areas. There shall be means to exclude hazardous quantities of smoke, flames or suppression agent from any occupied compartment. Live animal transport has to be considered.

d) If needed fire/smoke detection and fire suppression system shall be active during all flight phases and operational as long as the aircraft is electrically powered. If fire/smoke is detected, warnings (alarm) from the effected container shall be reliably transmitted to the aircraft.

e) The SmartContainer shall transmit all sensor data of the restraint system (e.g. (locked, unlocked, …) to the aircraft via one interface, during all flight phases.

f) For authentication the SmartContainer shall be registered with the aircraft at door area automatically.

g) The SmartContainer shall have a robust design for rough handling on airports as well as during loading and unloading (e.g. manual override). This typically considers pushing, pulling and step loads (e.g. anywhere abuse step loads of 2000N on an area of 200mm x 80mm, at pulling points / hand loops. a limit handling load of 1360N).

h) The HMI device as part of the A/C shall display the sensor information for each container.

i) The SmartContainer shall be designed for ground loading vehicle and cargo dollies/trailer transportation (aircraft/airport loader).

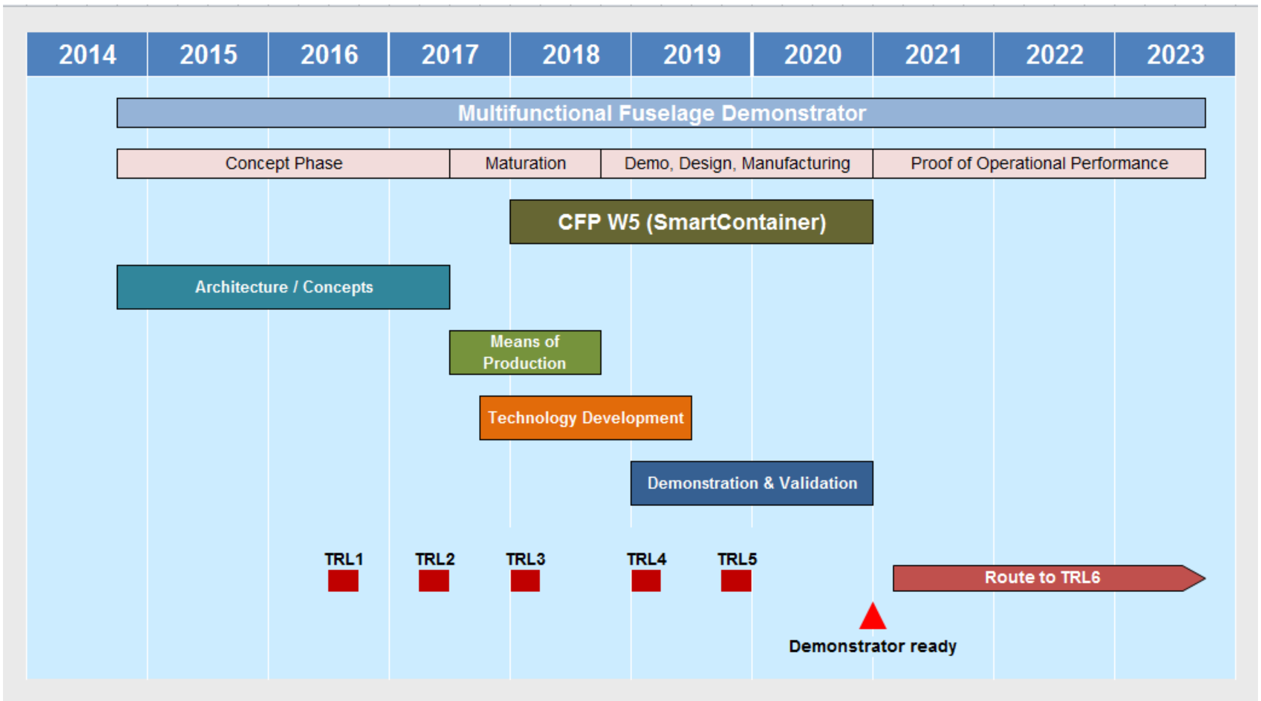
j) No single failure of the system or its components shall lead to unintended movement of ULD and any cathastropic failure condition during flight. FMEA shall be prepared to show that any catastrophic failure condition is extremely improbable, any hazardous failure condition is extremely remote and any major failure condition is remote.

k) Wireless communication shall not interfere any aircraft systems/component. The SmartContainer shall communicate with the aircraft via RFID or in combination with Wi-Fi.

l) The SmartContainer shall be compatible with the AS36100 K-Size baseplate.

m) Manual override function shall be considered in case of loass of power during ground operation or an inoperable transport system.

The time frame of the project is described in the following overall plan.



The objective of the call for partners is to provide hardware as defined for a development, integration and demonstration of the best candidate technologies. Different technologies can be demonstrated. Inputs will be given from the concept phase which is currently running, even though the applicants must bring in their own research resources.
The applicant will have full access to results and concepts, which have been selected in the concept phase. A comprehensive technical specification will be part of maturation phase and will be detailed during grant preparation.

The partner will be responsible for the following tasks:

- Define and work out functional & operational conditions across the different ATA chapter (e.g. ATA25, ATA53, ATA26, …) questioning the given state of the art requirements keeping in mind the certification basis, supported and validated by Airbus.
- Develop and investigate an innovative cargo SmartContainer incl. A/C-sided HMI and counterparts for container locking and wireless communication with new integration approaches.
- The development of the new cargo SmartContainer to be in line with a lean aircraft operation processes.
- Figures for weight, production costs and operational efficiency have to be reported.
- Develop a technology Verification & Validation (V&V) plan for the final concept that reflects the defined functional and operational requirements and perform virtual and physical full scale V&V tests in a close to real environment.
- Prepare means of compliance for certification of a highly integrated multifunctional concept.
- Define the interfaces to the aircraft.
- Manufacture and deliver a hardware SmartContainer demonstrator incl. A/C-sided HMI and counterparts for container locking and wireless communication for the aircraft demonstration.
- Provide the way to industrialization and implementation.

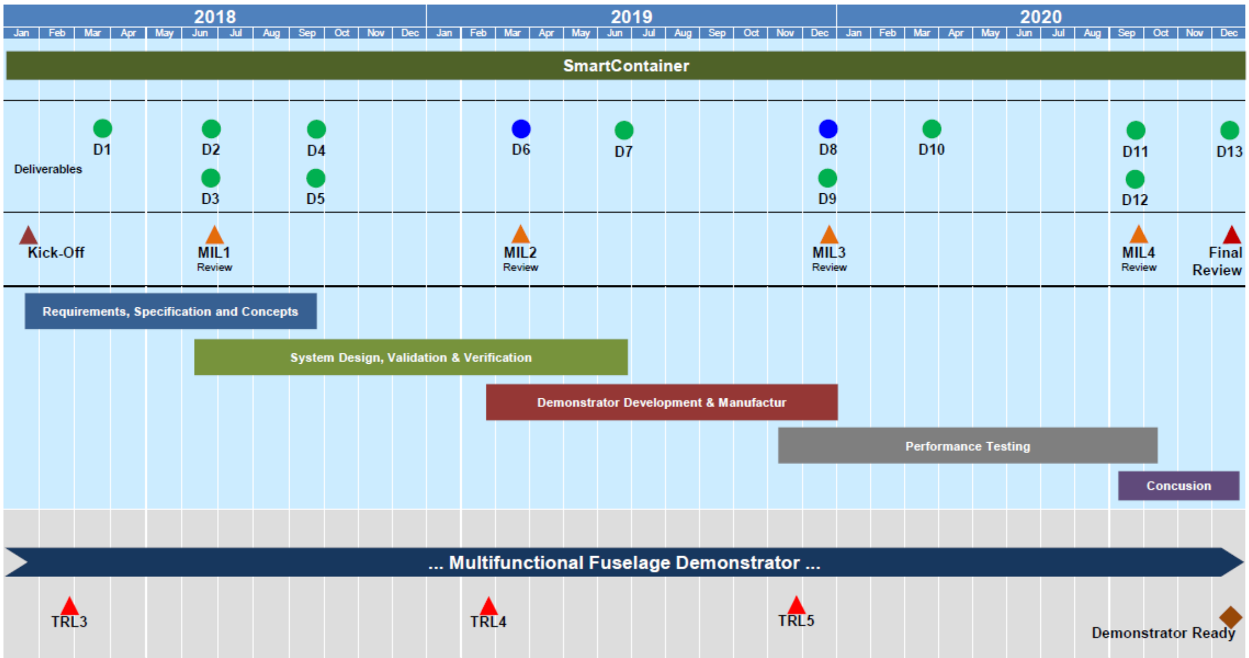
Role of the partners - Management and Coordination:

- Manage and coordinate partners
- Report project progress on a regular basis
- Manage and coordinate the progress meetings
- Manage and coordinate project activities on related subjects.
- Support and coordinate the reviews.
- Manage the configuration management process.

3. Major Deliverables and Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D1	Requirements compliance matrix	Report	T0+ 03 month
D2	Technology proposal of concept(s)	Report	T0+ 06 month
D3	Risk and opportunity matrix	Report	T0+ 06 month
D4	System description document including characteristics of the chosen solutions	Report	T0+ 09 month
D5	Proof of concept of characteristics and critical functions (FMEA)	Report	T0+ 09 month
D6	Component and breadboard validated in laboratory environment	Hardware	T0+ 15 month
D7	Test results - validated in laboratory environment	Report	T0+ 18 month
D8	Functional SmartContainer demonstrator incl. A/C-sided HMI and counterparts for container locking and wireless communication	Hardware	T0+ 24 month
D9	Test description for SmartContainer demonstrator	Report	T0+ 24 month
D10	Test results - validated in relevant environment	Report	T0+ 27 month
D11	Route to industrialisation including implications, risk mitigation, certification, verification management	Report	T0+ 33 month
D12	Technical and functional description of aviation approved SmartContainer incl. counterparts, operational handling and bill-of-material	Report	T0+ 33 month
D13	Final project report including lessons learnt	Report	T0+ 36 month

Milestones / GANTT chart



4. Special skills, capabilities

General skills, capabilities

- It is expected that the applicant has an aerospace industry background, experiences and capabilities in:
  - Aircraft ULD manufacturing
  - Cargo loading systems & handling
  - Powered drive units incl. control systems
  - Fire & smoke suppression systems
  - Wireless applications & protocols
  - Materials & processes (efficiency, characteristics, combinations, endurance, …)
  - Test benches & procedures (fire, smoke, toxicity, statics, robustness, endurance, …)
  - Functional analysis
  - Airworthiness requirements
  - Requirement based engineering
  - Aircraft certification regulations (across related ATA chapters, CS-25)
  - Integrated supply chain
  - Project management skills as requested in chapter 2
  - Verification management

- Furthermore, the applicant shall be able to demonstrate sound technical knowledge in the field of proposed contributions; he shall be able to demonstrate that this knowledge is widely recognized.
- The applicant shall demonstrate experience in-depth project management in time, cost and quality together with evidence of past experience in large project participation.

- It is intended that the applicant takes also responsibility for work package co lead (incl. co-developing the project management plan and closely monitoring the project progress) which in detail has to be defined during grant preparation.
- The applicant(s) shall demonstrate in-depth experience concerning performing environmental tests according RTCA-DO160.

An Implementation agreement will be proposed to manage the IPR and the relation between the Topic manager and the Applicant(s).

5. Abbreviations

A/C	Aircraft
AS	Aerospace Standard
ATA	Air Transport Association
CS2	Clean Sky2
CS-25	Certification Specifications for Large Aeroplanes Part 25
CSJU	Clean Sky Joint Undertaking
FMEA	Failure Mode Effect Analysis
HMI	Human Machine Interface
IADP	Innovative Aircraft Demonstration Platform
IATA	International Air Transport Association
ISO	International Organization for Standardization
JTP	Joint Technical Proposal
LPA	Large Passenger Aircraft
MCA	Major component assembly
NRC	Non-Recurrent Costs
PBS	Product Breakdown Structure
RC	Recurrent Costs
RFID	Radio Frequency Identification
S/C	Sub Contracting
SA	Single Aisle
SPD	Systems and Platforms Demonstrators
ULD	Unit Load Device
V&V	Verification & Validation
WBS	Work Breakdown Structure
Wi-Fi	Wireless Fidelity
WP	Work Package

IX. Glass fiber based temperature/air humidity and Agent detection sensors & measurement systems

Type of action (RIA or IA)	IA		
Programme Area	LPA		
Joint Technical Programme (JTP) Ref.	WP 2.2.3.1 Env. Friendly Fire Protection		
Indicative Funding Topic Value (in k€)	480		
Topic Leader	Fraunhofer	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	27	**Indicative Start Date**[9]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-LPA-02-17	**Glass fiber based temperature/air humidity and Agent detection sensors & measurement systems**
Short description	
For the evaluation of the impact of an environmental friendly fire protection system in the cargo hold and cabin a sensor and measurement system shall be developed and provided for the flight test facility consisting of agent detection, humidity and temperature sensors in Holzkirchen, Germany.	

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

1. Background

The Flight Test Facility (FTF) shall be the validation platform for Environmental Friendly Fire Protection (EFFP) system, which will be developed in the frame of the CS2 LPA programme. The FTF is a test platform based on a full cross section A310 airframe. It can be exposed to an environment representing flight and ground conditions wrt. external/internal temperatures and cabin pressure. For the validation of the EFFP a measurement system shall be emplaced on the FTF consisting of:

1. Data acquisition system: The calibrated measurement system shall provide the existing measurement systems for the FTF with innovative functionalities for agent detection and hygro-thermal properties in the cargo and cabin area. The acquired data of this system shall be accessible and usable for the existing FTF control system and support the automatic test procedure and test report creation. The system shall fit and remain in the existing measurement infrastructure of the FTF in Holzkirchen, Germany.

2. Electrical wireless temperature and humidity sensors: The humidity and temperature sensors shall provide sufficient precision and long-term stability and availability. The sensor system shall provide sufficient measurement points (400-600) based on glass fiber technology without electric wired sensors. The accuracy, resolution (location and time), reliability and achievable TRL of this system are the dominant criteria.

Compared to standard measurement systems, the use of glass fiber has the potential to reduce substantially wiring weight and improve the measurement accuracy. Potential aircraft applications will be envisaged during the project execution.

3. Novel agent detection sensors: The agent detection and gas sensors shall provide real time monitoring capability with low latency and significant noise-signal-ratio. Different detection sensors are required:

- Agent detection sensors shall provide: reliable detection of the fire knock-down and suppression agents in the relevant concentration, adaptability to specific gaseous agents. The adaptations shall be performable by the Fraunhofer research team
- Gas sensors for the detection of: O_2 and CO_2 concentrations

Sensors which can combine agent and O_2 / CO_2 measurement are preferred. Roughly 20 locations for simultaneous measurements are planned.

2. Scope of work

The work is separated into 5 different phases: The requirement alignment, the design phase followed by the development and production phase, the testing and qualification phase and finally the support phase. The final result shall be an equipped FTF with full test capability for EFFP tests. The demonstrator shall be capable to process the acquired data to the existing measure and control systems.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
1	Definition and harmonization of detailed requirements and interfaces	T0+2M
2	System design (Critical Design Review, CDR)	T0+4M
3	Development / adaptation / selection of the sensors and data acquisition systems → prototypes validated on Fraunhofer site	T0+12M

Tasks		
Ref. No.	***Title - Description***	***Due Date***
4	Manufacturing, installation and integration of the sensors and measurement system	T0+18M
5	Test readiness review for the EFFP demonstrator	T0+20M
6	Support during the testing phase of the EFFP demonstrator and completion of documentation	T0+27M

Task1 - Definition and harmonization of detailed requirements and interfaces

An analysis of detailed requirements for the sensors and data acquisition system with Topic Manager will be performed. The existing HW and the SW have to be reviewed to assure that the required HW interfaces can be integrated and that the SW provides the necessary features to assure the functionality and integration of the system with the existing control and measurement infrastructure.

Upon review of the existing control and measuring system, the physical geometry of the FTF and the selected fire protection/suppression agents, an analysis of specific requirements of the sensors and data acquisition systems is required. The requirements defined in this phase will be the basis for the following design phase.

Task 2 - System Design

HW: Definition of the components that are required on the demonstrator system:

- Electrical wireless temperature and humidity sensors (400-600)
- Agent detection sensors (ca. 20)
- Gas sensors (O2 / CO2) (ca. 20 combinable with agent detection sensors)
- Data acquisition system(s) compatible to measuring infrastructure at FTF

SW: Provision of first description of SW architecture able to comply to the required functionality to interface with the existing control and measurement infrastructure.

This phase is closed with the closure of the CDR actions.

Task 3 - Development / adaptation / selection of the sensors and data acquisition systems **of the sensors and data acquisition systems**

- Selection, adaptation and/or development of sensors to fulfill the requirements
- Production of the first prototypes of the sensors including integration of the prototypes into the data acquisition system
- Performance of validation test on Fraunhofer site, which will be accompanied by the Topic Manager.

Task 4 - Manufacturing, installation and integration of the sensors and measurement system

- Manufacturing of the sensors and data acquisition systems ready for integration into the FTF
- Documentation including calibration protocols of the produced sensors and systems
- Support for the installation of the sensors in the FTF
- Development and/or adaptation of the SW according to the definition of the CDR
- Creation of a user manual, which shall be used during the testing phase
- Installation of the SW on the computers of the Fraunhofer test facilities.

Task 5 - Test readiness review for the EFFP demonstrator

After the installation and integration on the FTF, the functionality of all components and the proper interfacing with the FTF-Systems shall be validated prior the start of the test campaign. This task is closed with the passing of the Acceptance Test Procedure (ATP) on the FTF, which is the main prerequisite for the test readiness review.

This task comprises support and participation for the test readiness review:

- Contribution to the validation matrix for all requirements.
- Participation at the acceptance tests in cooperation with Topic Manager.
- Train the operators and control system experts of the FTF on the demonstrator system.

This phase is closed with the successful performance of the ATP and the closure of the actions which arose during the validation phase.

Task 6 - Support during the testing phase of the EFFP demonstrator and completion of documentation

During the performance of the test campaign for the EFFP system in the frame of LPA 2.2.3.1 on-site and online support for the systems shall be provided, if required. During this phase the documentation of the systems shall be completed.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D1	Requirement and interface specification	D	T0+2M
D2	Requirement review	R	T0+2M
D3	HW and SW description	D	T0+4M
D4	Critical Design Review	R	T0+4M
D5	Validated prototype HW of the demonstrator System	H	T0+12M
D6	Integrated HW on FTF	D	T0+18M
D7	Documentation of installed HW/SW for the demonstrator system	D	T0+20M
D8	Delivery of final documentation	H / S	T0+27M

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Requirements review	R	T0+2M
M2	Critical Design Review	R	T0+4M
M3	Validated prototypes	HW	T0+12M
M4	HW installed and integrated	HW	T0+18M
M5	Test readiness review passed	R	T0+20M
M6	Documentation completed / remaining actions closed	R	T0+27M

Gannt Chart for deliverables and Milestones

	Deliverable	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	25	26	27
D1	Requirement and interface specification																											
D2	Requirement		M 1																									
D3	HW and SW description																											
D4	Critical Design Review				M 2																							
D5	Validated prototype HW of the demonstrator System												M 3															
D6	Integrated HW on FTF																		M 4									
D7	Documentation of installed HW/SW for the demonstrator system																				M 5							
D8	Delivery of final documentation																											M 6

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

- Excellent knowledge of control and measuring systems
- Excellent knowledge of agent detection sensors/ gas sensors
- Excellent knowledge of glass fiber based temperature and humidity sensors
- Excellent knowledge of HW development process and calibration needs

An Implementation agreement will be proposed to manage the IPR and the relation between the Topic manager and the Applicant(s).

X. Multi-Physics methodology for phase change due to rapidly depressurised two-phase flows

Type of action (RIA or IA)	RIA		
Programme Area	LPA		
Joint Technical Programme (JTP) Ref.	WP 2.2.3.1 Environmental Friendly Fire Protection		
Indicative Funding Topic Value (in k€)	400		
Topic Leader	Fraunhofer	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[10]	Q1 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CfP06-LPA-02-18	**Multi-Physics methodology for phase change due to rapidly depressurised two-phase flows**
Short description	
A multi-physics methodology should be developed to couple CFD calculations with models for phase change of rapidly depressurised mist of a fire suppression system. The methodology should be analytically described, implemented as a user defined function in a tool chain and coupled with the near-field CFD calculation to describe the penetration of a two-phase flow and phase transitions into the confounding space. Finally a parametric study for pre-defined cases should be performed and documented.	

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

1. Background

Currently the aircraft fire suppression system uses the gas Halon. Due to its high ODP (Ozon Depletion Potential) factor, this gas is prohibited in most applications except aircraft fire suppression. However, research for a suitable replacement is ongoing. Potentially, the fire suppression agent enters the cargo hold as a one phase or two phase flow. After injection, it rapidly decompresses from its injection pressure to the ambient cargo hold pressure. This decompression leads to a cool down of the agent and surrounding air and potentially to a (partial) phase change of the fire suppression agent. This phase change shall be predicted to and from solid, liquid and gasous state.
To predict the effect of the decompression of fire suppression agent, a phase change model of rapidly depressurized fluids shall be coupled to CFD computations. The aim of this simulation is to predict the penetration of the fire suppression agent into the confounding space. For this, the model shall be implemented as user defined function and integrated into a toolchain that allows coupling to the near-field CFD computation.
Model theoretical considerations, assumptions, empirical correlations shall be analytically described and model implementation shall be documented. To show the relevance of the implemented multiphysics coupling a parametric study shall be performed for pre-defined cases and suppression agents. This parametric study shall be documented and disseminated.

2. Scope of work

Tasks		
Ref. No.	***Title – Description***	***Due Date***
Task 1	Review of: requirements, two-phase and phase change models	T0+4M
Task 2	Implementation of suitable two-phase and phase change parametric model	T0+10M
Task 3	Coupling of two-phase and phase change model to CFD and development of associated toolchain	T0+15M
Task 4	Parametric Study based on dedicated fire suppression agents	T0+21M
Task 5	Documentation of model and model usage	T0+24M
Task 6	Dissemination	T0+24M

- Task 1: Existing two-phase and phase change models shall be reviewed and evaluated wrt. the envisaged application and requirements. Suitable models shall be selected for implementation.
- Task 2: The two-phase and phase change model shall be implemented to predict the behaviour of rapidly depressurized fire suppression agent.
- Task 3: A toolchain shall be developed to couple the two-phase and phase change model to near-field CFD simulation in order to predict the penetration depth of fire suppression agent in an aircraft compartment.
- Task 4: A parametric study of different fire suppression agent supply strategies shall be conducted using CFD and the coupling to the two-phase and phase change model.
- Task 5: The coupling of CFD and the two-phase and phase change model shall be documented to allow other users the setup of their own model. The usage of the model and associated toolchain shall be documented based on the parametric study.
- Task 6: The research work conducted in this project shall be disseminated through at least one peer reviewed journal paper and if applicable through suitable conferences.

3. Major deliverables/ Milestones and schedule

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Two-phase and phase change model approach review and requirements coverage report	DOC	T0+4M
D2	Two-phase and phase change model V1	SW	T0+10M
D3	Toolchain V1 to couple CFD and two-phase and phase change model	SW	T0+15M
D4	Parametric study on fire suppression agent injection	PRES	T0+21M
D5	Documentation of model and model usage	DOC	T0+24M
D6	Toolchain V2 to couple CFD and two-phase and phase change model	SW	T0+24M
D7	Dissemination Report	DOC	T0+24M

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M1	Requirements coverage and two-phase and phase change models reviewed		T0+4M
M2	Two-phase and phase change Model V1 delivered		T0+10M
M3	Coupling of two-phase and phase change model to CFD and development of associated toolchain		T0+15M
M4	Review of Parametric Study of two-phase and phase change model and documentation		T0+24M

Gannt Chart for deliverables and Milestones

	Deliverable	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
D1	**Two-phase and phase change models review and requirements coverage report**				M 1																				
D2	**Two-phase and phase change model V1**										M 2														
D3	**Toolchain V1 to couple CFD and two-phase and phase change model**															M 3									
D4	**Parametric study on two-phase and phase change**																								
D5	**Documentation of model and model usage**																								
D6	**Toolchain V2 to couple CFD and two-phase and phase change model**																								
D7	**Dissemination Report**																								M 4

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

The applicant shall present a convincing track record in the use of CFD and in the development of user-defined functions coupled to CFD. The applicant should prove that he/she has the means to perform a review of existing two-phase and phase change models and to implement most suited models into a user-defined function.
The applicant shall have a profound understanding of energy, enthalpy and mass flows during phase change.
The applicant shall be able to precicely and understandably synthesize the performed work into a documentation to enable other researchers to access the methodology.

An Implementation agreement will be proposed to manage the IPR and the relation between the Topic manager and the Applicant(s).

XI. High performance landing gear fitting

Type of action (RIA or IA)	IA		
Programme Area	Large Passenger Aircraft		
Joint Technical Programme (JTP) Ref.	WP 2.3.1.1		
Indicative Funding Topic Value (in k€)	400		
Topic Leader	Airbus	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[11]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-LPA-02-19	**High performance landing gear fitting**
Short description	
The objective of the proposed study is to develop the manufacturing method of a large landing gear fitting with high mechanical properties, low buy to fly ratio and reduced distortions thanks to: new generation alloys, optimised geometry, design to forge, or others.	

[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.

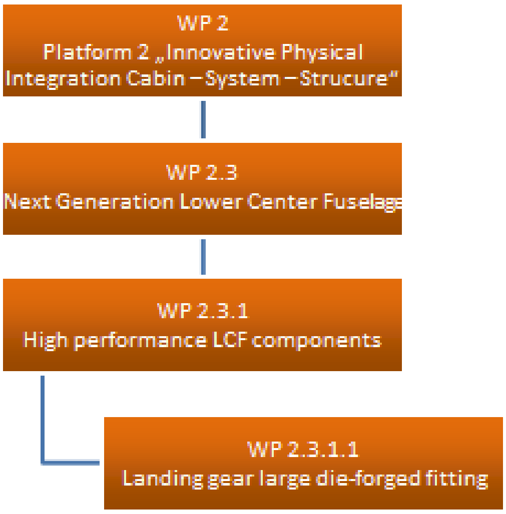


Figure 1

Next generation Lower Center Fuselage WP2.3 is based on the Body Landing Gear scenario. In order to offer more flexibility to the improvements 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 fittings. The subject of this topic 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, an over thicknesses has to be added to the forging angles. This added material leads to a large quantity of material removal during the machining, and thus, lower buy to fly ratio and to non-negligible distortions.

The objective of this study is to get from the applicant the guarantee that the projected large fitting can be die-forged, with high mechanical properties at reasonable cost. A way to obtain this is to forge a blank as close as possible to the final part shape; this will lead to optimal mechanical properties after the thermal treatment, less machining, and also reduce the distortions after machining.

Forging operations, and other associated operations are very energy consuming, so another objective should be minimize the number of operations and mitigate the energy consumption.
To do so, an innovative manufacturing process must be proposed to reduce the gap between the final part and the blank to a minimum, with a reduction of the recurring cost of the overall manufacturing of such part. Design modifications and alternative alloys will also be considered.

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 study the balance between the mechanical properties and the manufacturability. Such fitting will be submitted to high static and fatigue loads and the applicant must demonstrate that this part can sustain these loads via coupon testing.

The detail design of the fitting is not frozen, but the dimensions of the overall envelop of the final part will be around 1m50 * 1m50 * 1m thick, around 100 kg each (see figure 2 below).
The final part will contain large pockets, which can reduce locally the thickness to less than 1cm.

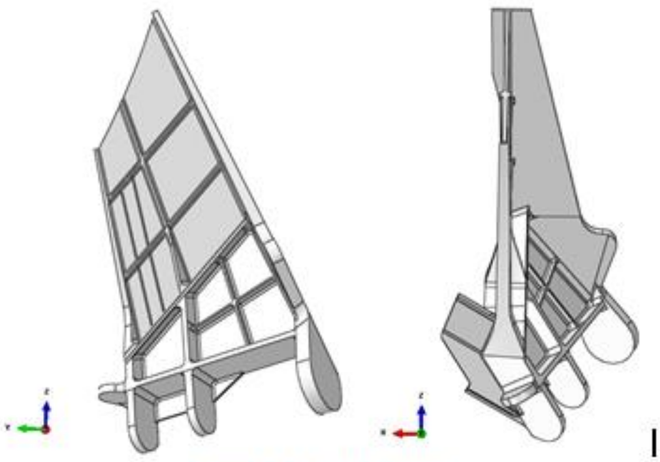


Figure 2 Main LG Fitting

The applicant will define and pursuit with Airbus a TRL4 with a final goal of a full scale demonstrator of the fitting with the desired mechanical properties, low buy to fly and reduced distortions.

The 2-years project will start on a TRL2 gate regarding feasibility, selection of material and manufacturing process; from which will develop tests and simulations leading to a TRL3 gate with reduced but representative scale demonstrator of performance and distortions.

The main challenges of this R&T project are:

- Produce large, complex 3D forged part, with deep pocketing
- Reduce distortions (reduce cost, operations and lead time)
- Optimise buy to fly ratio (reduced cost, energy and more ecologic design)

Several activities will be conducted for this project.

- Simulation of different materials to manufacture the part. Selection of the 2 best materials candidates regarding performance, weight and feasibility.
- Simulation of machining strategy in order to simulate residual stresses release
- Specimen mechanical test campaign to characterize the materials, depending on if new alloy and not qualified yet, or different thickness than already qualified range
- Use of testing and simulations to select the best material and forge strategy.
- Manufacturing of different thicknesses coupons with 3D geometry representative of the fitting and machining to check the distortions levels
- Optimise the design and manufacturing process of the blank for optimum forgeability.
- Manufacturing of the final dye and prototype (full scale demo)

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	Feasibility analysis of the proposed geometry	M0 + 3M
T4	Initial simulations to select materials and forging strategy	M0 + 6M
T 5	Mechanical test of specimens to characterize the material for several thickness (if alloy/thickness not qualified yet)	M0 + 10M
T 6	TRL2 with selection of material/forging process	M0 + 10M
T 7	Detailed simulations of the selected choice	M0 +13M
T 8	Definition of the shape of the representative 3D geometry coupons of different thickness including machining simulation	M0 +14M
T 9	Forging of 3D coupons with several thicknesses	M0 + 16M
T 10	Machining of coupons for distortions evaluation	M0 + 17M
T 11	TRL3 with proof of concept representative feasibility demonstrator	M0 + 18M
T 12	Definition of the shape of the die-forged blank	M0 + 19M
T 13	Tooling manufacturing completion	M0 + 21M
T 14	Full scale demonstrator manufacturing and delivery to Airbus	M0 + 22M
T 15	TRL4 with full scale demonstrator	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	**Feasibility study conclusions.** Regarding also forging parameters and final potential materials	Report	M0 + 3M
D 3	**Mechanical behaviour,** coupon testing campaign results (facultative)	Report	M0 + 10M
D 4	**Detailed simulation** of the selected material and process	Report	M0 + 13M
D 5	**Final Design** of the blank and manufacturing process definition	Report	M0 + 19M
D 6	**Tooling Manufacturing**	Report	M0 + 21M
D 7	**Full Scale demonstrator forging**	Report	M0 + 22M

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M 1	Forging feasibility	Technology review	M0 + 3M
M 2	TRL 2	Technology review	M0 + 10M
M 3	Feasibility demonstrator machining	Technology review	M0 + 17M
M 4	TRL 3	Technology review	M0 + 18M
M 5	TRL 4	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 coupons of different alloys
- 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 experienced staff in numerical simulation and manufacturing route definition
- 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)

An Implementation agreement will be proposed to manage the IPR and the relation between the Topic manager and the Applicant(s).

XII. Keel beam manufacturing oriented solution

Type of action (RIA or IA)	IA		
Programme Area	Large Passenger Aircraft		
Joint Technical Programme (JTP) Ref.	WP 2.3		
Indicative Funding Topic Value (in k€)	600		
Topic Leader	Airbus	Type of Agreement	Implementation Agreement
Duration of the action (in Months)	18	Indicative Start Date[12]	Q1 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CfP06-LPA-02-20	**Keel beam manufacturing oriented solution**
Short description	
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 robust solution compliant with high production rate and fast production ramp up.	

[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 Centre Fuselage" and belongs to the WP 2.3.1 "High performance LCF components", with the objective to develop Design to Cost proposals (Figure 9).

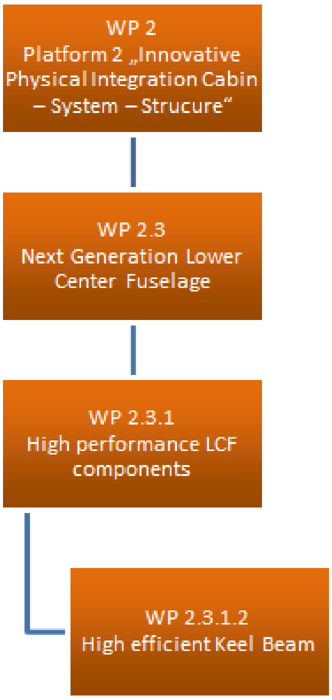


Figure 1

The Lower Centre Fuselage is composed of several Work Packages and this topic relates to the Keel Beam (WP 2.3.1.2). It will deal with airframe engineering and manufacturing domains.

The project targets an implementation within a new short range aircraft development to be launched by Airbus.
As such, the applicants will have to propose innovative technical solutions that meet the very challenging requirements coming from both Airbus and the airline: low production costs and weight.

Composite materials are preferentially used for unidirectional loaded parts for which the weight benefit over metal is significant.
The Keel Beam, being a highly loaded part in compression, is one of them and the associated benefits have already been proven on long range aircrafts such as A340 and A350.
However the cost of composite structures is very high compared to the traditional metallic concepts.

The objective of this study is to propose a composite keel beam scenario, for a short range aircraft.
The competitiveness of the solution is of paramount importance as the applicant is expected to demonstrate that its approach will significantly reduce manufacturing costs compared to actual composite technologies and be ideally comparative to metal ones.

The applicant must also demonstrate that the proposed **manufacturing and assembly processes enable a production rate over 70 aircrafts a month**, with a good robustness, aiming at a very high ramp-up (Full production rate in 4 years).

2. Scope of work

The keel beam is a major component of the lower part of the centre fuselage (figure 2), mainly loaded in compression. On short range aircraft such as A320, this component has to sustain approximately 200tons. Its length is around 6 meters (figure 3).

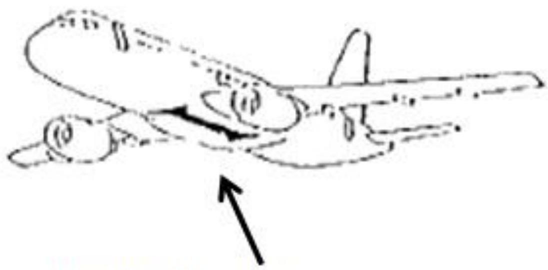


Figure 2: Keel beam location

Figure 3: A320 metallic Keel beam

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

- to rear fuselage at the rear pressure bulkhead
- to forward fuselage at the front pressure bulkhead
- to the centre wing box lower cover

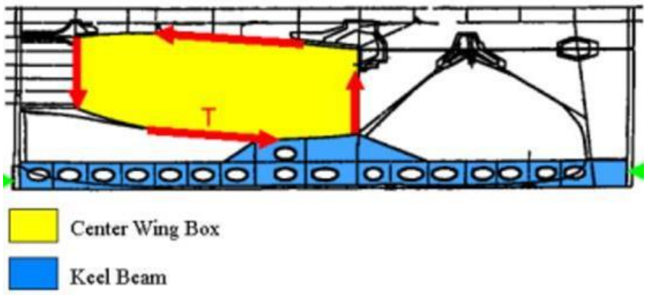


Figure 3: Keel-beam interfaces (A320 sketch)

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

Project objectives

This project aims at developing a **manufacturing oriented keel-beam (compatible with high production rate)** at an affordable cost for a short range aircraft such as A320. The material used for this development is thermoplastic composite.

The today reference for such a part is the A350 composite keel beam

The concept relies in 4 panels assembly (see figure 5), manufactured with thermoset prepreg materials using well known technologies such as AFP or ATL and autoclave curing cycle. The lower and upper covers have composite stringers and the internal ribs are bolted to the panels.

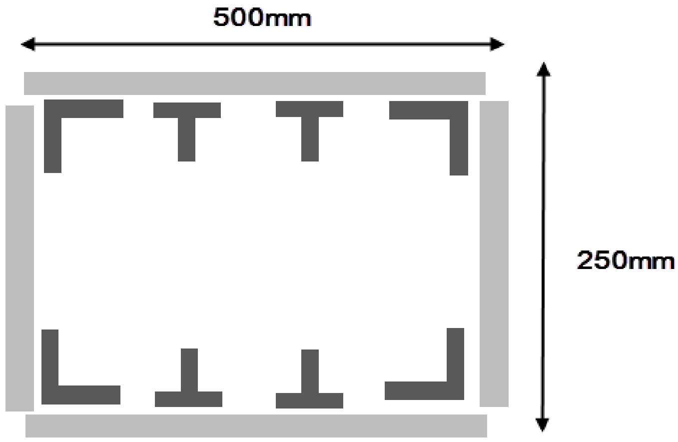


Figure 4: General cross-section assembly concept (rib not represented)

Considering a potential adaptation to A320 environment, the downscaling exercise of A350 keel beam was already performed by Airbus (cross-section, length) and assessed in terms of manufacturing and assembly. The results show that the price of the keel beam is very high, and not competitive versus a metal solution

In fact the process for these 4 panels, including rib integration, is **time consuming** and therefore **very expensive**.

Assembly represents most of the manufacturing price of the component.

With the present technologies and processes, high production rates are not achievable.

In order to take **full benefit of the composite properties** for the future aircraft development, the focus needs to be on **assembly time reduction** through **innovative concepts and technologies** such as thermoplastic welding, rib and stringer integration (one shot concepts, extrusion…) and others.

At the end, the innovative proposal will lead to **low** manufacturing and **assembly costs** together with a reduction of the operating costs for the airline (weight reductions).

Applicant's mission

- Concept Phase:

The applicant will be responsible of the selection of the thermoplastic composite material and the associated design. An innovative solution must be proposed taking into account the high mechanical loading of the component and the **strong requirements in terms of assembly time**.

The KB design solution may also be changed in order to take full benefit of the technology and process choices (number and shape of the ribs, stiffening choice …) with respect to the input envelops and interfaces.

The deliverable will be a final report presenting the design and stress activities (down selection of the concept/techno, preliminary weight assessment…), together with a Value and Risk presentation. The 3D mock-up of the selected solution will be also provided.

- Manufacturing Phase:

The manufacturing route is the **key aspect** for this project. The applicant must indeed demonstrate that the process used to manufacture and assemble this part is robust and can be applied to high production rate programs (over 70 aircrafts per month) with a**n Eco Design approach.** The deliverable will be a report explaining:
- The manufacturing route (including detailed assembly process, overall assembly line),
- The elementary part constitution (material, techno, maturity of the techno if it is in development),
- The industrial capabilities needed to ensure a high production rate,
- An overall manufacturing assessment of the solution (kg of material needed, labour hours for elementary part constitution, hours for assembly, € for standard part).

The comparison with the reference solution will be done by Airbus in order to achieve the expected RC savings

At least one trial specimen should be manufactured for the end of the study with the following features:
- Full scale cross section, with representative thicknesses,
- 1 meter long,
- the selected material,
- with representative industrial conditions.

- Planning

The maturity level to reach at the end of those 18 months activity is TRL3 meaning that:
- 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 + 1M
T 3	Concept phase	M0 +10M
T 4	Manufacturing route	M0 + 14M
T 5	Demonstration phase	M0 + 16M
T 6	Value and Risk analysis	M0 + 18M

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 + 1M
D 2	**Design solution down selection based on quantitave engineering assessment**	Report	M0 + 6M
D 3	**TRL2 Maturity**	Presentation	M0+7M
D 4	**Detailed definition of the selected solution + pre sizing of the keel beam components (parts + junction)**	3D mock up (Catia V5)	M0+12M
D 5	**Manufacturing route**	Report + assembly line proposal	M0 + 14M
D 6	**Demonstration phase** Feasibility study, report	Report, CAT Parts	M0 + 16M
D 7	**TRL3 maturity** Value and Risk analysis	Presentation	M0 + 18M

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M 1	TRL 2	Technology review	M0 + 7M
M 2	TRL 3	Technology review	M0 + 18M

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

Mandatory skills:

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

Mandatory capability

- CAD Software : CATIA
- Numerical simulation Software
- Manufacturing facilities and equipment

An Implementation agreement will be proposed to manage the IPR and the relation between the Topic manager and the Applicant(s).

XIII. Development of Systems for Automated Testing in the Aircraft Interior

Type of action (RIA or IA)	IA		
Programme Area	LPA		
Joint Technical Programme (JTP) Ref.	WP 2.4.4 – [Future Factory]		
Indicative Funding Topic Value (in k€)	1000		
Topic Leader	Fraunhofer	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	30	**Indicative Start Date**[13]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-LPA-02-21	**Development of Systems for Automated Testing in the Aircraft Interior**
Short description	
The future assembly of linings and hatracks in cabin and cargo will require an automated testing system. This topic will deliver tools and test strategies for an efficient gap and flush management and surface quality inspection of the installed components.	

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

1. Background

The future aircraft factory would be inadequate without the consideration of essential automation technologies. In order to achieve a TRL 6 (Technology Readiness Level 6) in innovative testing systems like the one established here, safe procedures are of vital significance and a main criteria in the validation process. Today, testing of the aircraft includes gap and flush management of cabin and cargo installation as well as the quality inspection which are still carried out manually. A large number of these activities are in non-ergonomic conditions, process chains are extremely complex and insufficiently transparent. Also, there are tight restrictions in working space and all procedures require a specific level of flexibility to guarantee a smooth work flow even if sudden changes occur in the availability of resources. The testing of the interior components in the cabin and cargo areas will require an automated system to support human work force.

With the assistance of automated testing-tools, this project delivers the premise for the related tolerance control and quality check of the cabin interior final assembly (see Figure 1). This shall also integrate possibilities to optimize process chains and ensure transparency of the current assembly status at all times. There are challenges in numerous perspectives, as for instance the constrained access inside the aircraft, the need of an interface to moving autonomous automation systems through aircraft interiors and the data processing.

Such automated testing tools will be a leap forward with regard to lead time, recurring costs, flexibility and transparency.

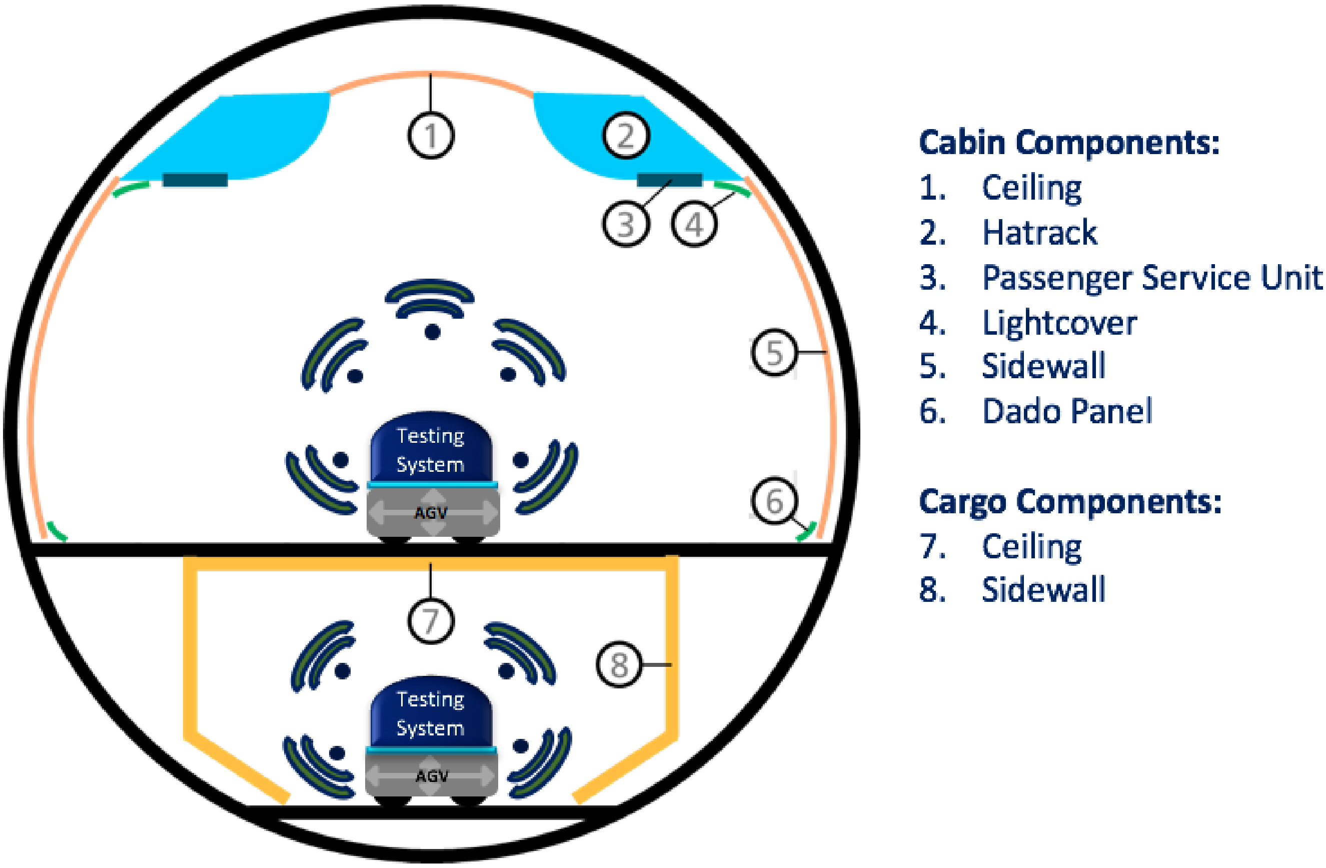


Figure 1. Cabin and Cargo Assembly Environment

2. Scope of work

The main scope of this project is to develop a system for automated testing on the base of an already available mobile system for cabin and cargo assembly. The tests to be performed are the gap and flush management of installed components including lining and hatracks and the quality of the aircraft interior such as textures, defects and colour. Those tests are defined by the current standards and requirements by A/C manufacturer. For this purpose, an important step forward from the state of technology is the quick measurement to generate quality data (3D data) and automated data evaluation. The final result is a visualization and documentation of imperfections, which is needed for subsequent rework processes. Work packages and tasks to be accomplished are shown listed in the table below.

Tasks		
Ref. No.	***Title - Description***	***Due Date***

WP 1	Defining all requirements to establish and select concepts for the automated testing of installed components inside the aircraft (except seats) listed in figure 1.
	▪ Defining of requirements for the testing of cabin and cargo interior components in post installation phase for following four use cases:
	    ▪ Tolerances of the components with respect to positioning, gap and flush
	    ▪ Texture of the surface to meet the requirements of the A/C manufacturer
	    ▪ Defects on the surface of the aircraft interior components
	    ▪ Spectral analysis, specifically colour of the interior components
	▪ Concepts and requirements for the measurement system to detect gap and flush and for the inspection of the surface quality with respect to sensor accuracy and real-time management
	▪ Concepts for integrating the testing equipment into the aircraft on a mobile system (e.g. AGV)
	▪ Assessment of results together with the topic manager and the A/C manufacturer
		t_0 +15

WP 2	Selection and testing of suitable Hard- and Software for each use case regarding cabin and cargo testing requirements. Testing of the developed systems for each use case has to be conducted at the facilities of the call partner. ▪ Development and Visualization of test strategies for all four use cases ▪ Selection and test of 3D measurement system for automated scanning of the entire cabin and cargo area for position, gap and flush management ▪ Selection and test of an automated system for the surface quality inspection: Colour, texture and defects ▪ Defintion of relevant output data formats (quality report) and quality criteria regarding the tolerances of the interior and the surface quality	t_0 +21
WP 3	Development and integration of the final system for all four use cases with the required hard- and software interfaces. Final integration of the system will take place at the facilities of the topic manager. ▪ Integration of the automated 3D-measurement module for tolerance management and the inspection module for surface quality ▪ Enabling the system to generate and display the quality report considering the actual tolerances and surface quality of the aircraft interior ▪ Design of interface for data transmission between developed system and Augmented Reality (AR) ▪ Hard- and Software final integration of the completed modules into a single overall mobile system (e.g. AGV). Mobile system will be final developed at the latest until t_0+24 by other projectpartner.	t_0 +27
WP 4	Functional testing of the overall system and evaluation of the fully automated test procedure in cabin and cargo environment at the facilities of the topic manager. ▪ Final functional test of the entire mobile system ▪ Evaluation of the entire mobile system	t_0 +30

3. Schedule for Major Deliverables/Milestones (Estimate)

Milestones			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M 1.1	Completion of the requirement and concept phase of testing processes	Report	t_0 +15
M 2.1	Completion of design and preliminary testing of the developed concepts	Report and simulation	t_0 +21
M 3.1	Completion of the development and integration of the final automated testing system	Report	t_0 +27
M 4.1	Completion of the evaluation process	Report, simulation and demonstration	t_0 +30

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 1.1	Requirements of the automated measurement system and test strategy	Report	t_0 +6
D 1.2	Evaluation matrix of concepts for the four use cases	Report	t_0 +9
D 1.3	Results of assessment for automated testing concepts	Report and visualization	t_0 +15
D 2.1	Test results of the developed systems for each use case	Report and simulation	t_0 +21
D 3.1	Data management Software for generating of qualtiy report	Software	t_0 +21
D 3.2	Interface for data transmission between developed system and Augmented Reality (AR)	Software data and simulation	t_0 +24
D 3.3	Final integration of the completed testing system into a mobile system at the facilities of the topic manager	Hardware and Software (testing system)	t_0 +27
D 4.1	Final functional test of the entire mobile system	Report and demonstration of the mobile testing system	t_0 +27
D 4.2	Evaluation of the entire mobile system	Report	t_0 +30

	Year 1				Year 2				Year 3	
Activity *months → t_0*	+3	+6	+9	+12	+15	+18	+21	+24	+27	+30
WP1 Defining all requirements to establish and select concepts for the automated testing of installed components inside the aircraft (except seats) listed in figure 1.		D	D		M D					
WP2 Selection and testing of suitable Hard- and Software for each use case regarding cabin and cargo testing requirements. Testing of the developed systems for each use case has to be conducted at the facilities of the call partner.							M D			
WP3 Development and integration of the final system for all four use cases with the required hard- and software interfaces. Final integration of the system will take place at the facilities of the topic manager.							D	D	M D	
WP4 Functional testing of the overall system and evaluation of the fully automated test procedure in cabin and cargo environment at the facilities of the topic manager.									D	M D
Reporting Periods	*12 months →*				*12 months →*				*6 months →*	

***D = Deliverable & M = Milestone**

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

The applicant(s) shall have experiences in different disciplines of automated measurement systems. The applicant's focus should be in the field of aircraft production and assembly including all main aspects of a production system.

- Interdisciplinary research and development team/consortium competent in different automated measurement systems within the cabin and cargo environment
- Experience in using aircraft requirements and informations
- Experience in future aircraft interior development and cabin and cargo architecture
- Experience in varied range of 3D scanning systems used within aircraft industry
- Knowledge in spectral colour analysis and aircraft colour and trim experience
- Solutions for texture analysis for different materials
- Experience in the integration of different IT systems
- Experience in the development of testing strategies
- Access to facilities for carrying out testing operations and the necessary 3D data
- Ability to replicate the aircraft environment with regards to actual tolerance
- Knowledge and skills for process monitoring and in line quality assurance within the aircraft industry
- Experience in system development for test operations in restricted and complex environments
- Experience in establishment of data interfaces between measurement and mobile system
- Experience in establishment of data interfaces between measurement results and augmented reality
- Experience in development of software for data management
- Competence and experience in 3D visualization of test information and provision of measurement data

An Implementation agreement will be proposed to manage the IPR and the relation between the Topic manager and the Applicant(s).

XIV. Image based landing solutions for Disruptive Cockpit concept

Type of action (RIA or IA)	IA		
Programme Area	LPA IADP - Platform 3		
Joint Technical Programme (JTP) Ref.	WP3.1		
Indicative Funding Topic Value (in k€)	1700		
Topic Leader	Airbus	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	48	**Indicative Start Date**[14]	Q1 2018

Topic Identification code	**Topic Title**
JTI-CS2-2017-CfP06-LPA-03-09	**Image based landing solutions for Disruptive Cockpit concept**
Short description	
In the frame of Disruptive Cockpit concept, the goal is to extend the aircraft automatic landing capability by using runway acquisition and tracking algorithms hosted on a dedicated image processing platform. The activities will cover the operational concept, system architecture, system specification, interface specification, system development, ground testing, support to flight testing, global V&V and performance assessment. The target is to reach TRL5 maturity by end of the project 2021.	

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

1. Background

Aircraft automatic approach and landing function aims at reducing crew workload and significantly improving safety. But current automatic approach and landing procedures rely on specific airport infrastructure such as ILS CATII and CATIII. These infrastructures are expensive, Airports presenting means compliant allowing an automatic landing are less than 20% of existing airports used by Airbus customers.

Hence the final approach and landing often rely on the pilot skills in manual flying. Thus, to improve aircraft operability, extending the automatic landing capabilities without having to fully rely on airport infrastructure is of key importance.

For several years Airbus Group has been working in the definition of innovative solutions to reduce crew workload in stressful situations as landing. One of the techno streams explored is the use of image information as a complement of current navigation data, either as a monitoring layer or as a back-up. These works have allowed Airbus to identify and characterize some features from an image that can help to improve approach and landing operation. The next step is to bring these ideas to a high level of TRL collaborating with a partner.

The framework of this topic is the LPA IADP - Platform 3, Technology Stream "(WP3.1)", in particular, those functions and solutions for man-machine efficiency.
The goal of this call is to explore and evaluate the implementation in real conditions of an airborne image processing platform including algorithms dedicated to runway acquisition and tracking, to be used for aircraft guidance.
Precisely this topic will be part of the work package "Image Based landing".

2. Scope of work

The objective of this Call for Partner is to define relevant requirements and to develop a platform hosting image based Algorithms to be used for approach and landing system that can provide the capacity to land the aircraft either independently or integrated with existing landing means.
Based on the operational concept and system specification provided by Airbus, the partner activities will cover system architecture definition, interface specification, system prototype development, integration support to ground and flight testing, global V&V and performance assessment. The target is to reach TRL5 maturity by end of the project in 2020.
This partner shall provide industrial image processing solutions compliant with Airbus needs in terms of execution time, safety level, performance, etc.

Airbus has led a preliminary study based on a high resolution monochrome camera in the visible wave lengths and a real time processing algorithm to detect and track the runway during approach. VFR sensor is a first step to work with because of data availability and for simplicity. However algorithms shall be applicable to other frequency range, at least IR.
This preliminary study can help defining the operational concept and the system architecture.
Partner will have to provide algorithms capable to detect runway characteristics (e.g. centreline, touchdown point, side lines) in a video sequences in approach, initially in the visible wave length. However, the system developed by the partner is expected to be flexible and evolving. As consequence, an analysis of the adaptability of the algorithms shall be performed, that is,

1. Detail the minimal characteristics of the image that should be compliant with the proposed algorithms (sensors are not part of this call but supplier may suggest potential solutions).
2. Identify potential V&V methods for the algorithms and the impact of the frequency range
3. Provide the characteristics and the main constraints of the algorithms in terms of computational cost, resolution required, and performance.

For instance the frame of this study is opened to possible integration of different video streams provided by different sensors as optical in visible or IR band or from others as radar. Airbus will provide some benchmark videos, initially in the visible band, that could be used to evaluate the performance of the algorithms. However the partner will base the development process in synthetic images. Afterwards, IR band videos can be provided to evaluate the flexibility of the algorithms.

The system interfaces will have to comply with a set of image sensors to be defined (sensors are not included in this call), especially visual and IR sensors.

The system avionics will have to host different and independent real time image processing algorithms, integrated as field loadable items.

The definition and development of a prototype of the system is required to expose the algorithms in the WP3.5 Disruptive Cockpit demonstrator as well as in the WP3.3 demonstration flight test. Airbus targets a unique system for video management and processing. Hence this system will have to be able to acquire several video flows on different video input interfaces, switch that flows to different real time processing algorithms, send resulting video flows to different output video interfaces, with DAL, latency, time partitioning and spatial partitioning constraints.

The system will also acquire avionics parameters (such as inertial data or air data) required for video processing algorithms and send back to avionics systems some new or consolidated parameters resulting from video processing.

Input video interfaces can be from visible cameras, infrared cameras, radar imagers, etc. The sensors themselves are not part of the call, but the characterisation of the video inputs will have to be specified in terms of physical links and protocols (A818, Ethernet, SMPTE …), data format, image quality (resolution, colours, distortion, signal to noise ratio, etc.)

Output video interfaces can be to cockpit display, HUD, HMD, and also cabin/IFE. Baseline format of the video flow that Airbus is targeting is ARINC818 and Ethernet.

Even if the TRL5 prototype should not be designed for certification in the frame of this study, the certification constraints shall be taken into account from the beginnng. Then the partner will propose a process to achieve the level of demonstration required with respect to the authorities considering, for instance, JAR AWO.

As the goal of this call is to achieve a level of maturity equivalent to TRL5 the partner will be required to collaborate with Airbus in the integration of the solution provided in the flight test demonstrator of the Disruptive Cockpit concept. A prototype of the image processing system (Image processing platform and algorithms) will be provided and interfaced with the Airbus systems in collaboration with Airbus integration teams. Flight testing are planned after delivery of TRL5 like prototype on end 2020, and preparation are part of Task 6 & 7

Key skills for specifying and developing such system are time critical video processing hardware and software, DAL A avionics constraints knowledge and modular avionics knowledge.

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 image processing system composed of an image processing platform and image processing

algorithms, 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 defining a certification strategy for the image processing based technology
e) Support Airbus during the integration, tests and validation of the prototypes on Airbus simulator 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.	01-2018 to 04-2018
Task 2	**Definition of requirements** - Requirements shall be defined at A/C, System and equipment level to support the scenario of A/C approach and landing. The requirements shall include the image processing platform and the hosted algorithms	03-2018 to 10-2018
Task 3	**Validation & verification plan -** For each requirement a proposed means of compliance shall be defined for the validation & verification process.	10-2018 to 01-2019
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: • System architecture • Image processing platform and algorithms • Operational use	07-2018 to 06-2019
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	06-2019 to 10-2020
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.	10-2020 to 10-2021
Task 7	**Final Report –** All results shall be formalized in the final report.	10-2021 to 12-2021

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	05-2018
D2	**System Requirement Document –** Compilation of relevant requirements.	Document	10-2018
D3	**Validation & Verification Plan –** Definition of the validation & verification process.	Document	02-2019
D4	**System Definition Document –** Description of the potential concepts.	Document	02-2019
D5	**Validation prototypes for most critical building blocks (TRL4)**	Prototype	-2020
D6	**Full scope verification prototype (TRL5)**	Prototype	08-2021
D7	**System Validation & verification Report** – Compilation of evidences from the validation & verification process.	Document	10-2021
D8	**Final Report**	Document	12-2021

Milestones			
Ref. No.	***Title – Description***	***Type***	***Due Date***
PDR	**Preliminary Design Review** Review of the system High Level Requirements, solutions to be evaluated and main building blocks to be prototyped.		Before task 5
DR	**Design Review** Review of the trade-offs, definition of the system architecture to be tested.		Before task 6
TRR	**Test Readiness Review** Review of the prototypes to be tested and test procedures.		Before task 7

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 image based systems for the aerospace industry.
b) Knowledge and experience of image processing algorithm for civil or military aircraft environments, including object identification and tracking.
c) Knowledge and experience in time critical and safety critical modular avionics and video processing for avionics.
d) Knowledge and experience in aircraft operation at approach and landing, certification constraints (JAR AWO) and current landing technologies.
e) Experience in image sensors characterization for civil or military aircraft environments, including at least visible and infrared frequency ranges.
f) Working prototypes (even at low maturity level) demonstrated of one or several building blocks of the targeted system.

XV. Avionics Technologies Management solution for Pilot Workload Reduction

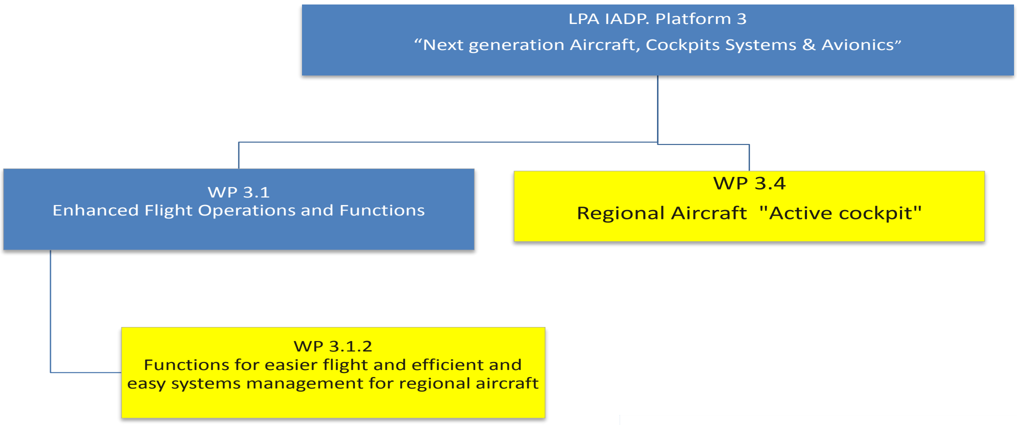
Type of action (RIA or IA)	IA		
Programme Area	LPA IADP - Platform 3		
Joint Technical Programme (JTP) Ref.	WP3.1.2		
Indicative Funding Topic Value (in k€)	1400		
Topic Leader	Airbus D&S	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[15]	Q1 2018

Topic Identification code	**Topic Title**
JTI-CS2-2017-CfP06-LPA-03-10	**Avionics Technologies Management solution for Pilot Workload Reduction**
Short description	
The aim of this topic is to enhance the technologies that contribute to alleviate the Pilots in their ground and flight tasks, by using a combination of image recognition sensors (EO/IR), A/C sensors and equipment to develop tracking and command algorithms hosted on a dedicated computing platform. The target activities will focus on defining the System Requirements, Architecture and its associated interface requirements, System Definition, Specification and Development, System V&V plan and support to on ground testing and system performance evaluation with the Human Factor perspective.	

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

1. Background

In the framework of the Platform 3 of the Clean Sky 2 LPA IADP several technologies for pilot workload reduction are being developed by Airbus Defence and Space in WP3.1.2 "Functions for easier flight and efficient and easy systems management for regional aircraft".
It is well-known that an increase in situational awareness and automation would definitely be beneficial, driving also an increase in aircraft safety margins. Thus, growing in safety through automation in complex ground and flight phases has become a priority in order to fulfill future SESAR & NextGen regulations.
Each technology is developed with the aim to achieve, at least, TRL-5 by the end of the project, both in a stand-alone and in an overall operating scenario in the Active Cockpit ground demonstrator, where each technology will interact with the others. The Active Cockpit provides a flexible cockpit layout reconfigurable to different representative twin pilot cockpits using multi-touch displays for interaction and virtual representation.



Excerpt of LPA Platform 3 work break structure

In particular the purpose of this topic is to design and manufacture a system prototype (HW&SW) to integrate, enhance and manage the interfaces of the different pilot workload reduction solutions (Eye Visor, Voice Command, Procedure Automation, Pilot Monitoring and A/C Monitoring Chain for ground support).

In order to complement the above mentioned technologies the partner will also develop a "visual recognition & command system" to reduce significantly the pilot tasks in airports with high density of traffic. Once implemented this innovative function shall provide the required data and shall exploit them through guidance algorithms to execute the take-off, final approach and airport navigation operations in automate guidance mode.
Currently take-off and non-precision approaches operations require the flight crew control. Only CAT3 ILS approaches provides auto-land capability, however other type of approaches requires also visual contact with the runway.
Airport navigation is currently based on airports maps to help the flight crew to taxi but still requires the flight crew control to steer the aircraft and to avoid unexpected obstacles such as aircraft or airport

vehicles incursions.
Through visual image recognition using visible and infra-red light spectrum with the addition of automatic flight control, automatic thrust control and autobrake this function will provide autonomous aircraft steering.

In the same line the partner is requested to explore and propose **an automatic aircraft response** to the Traffic Collision Avoidance System (TCAS) and Terrain Awareness and Warning System (TAWS) and Weather Radar (WXR) warnings to avoid collision with other aircrafts, with the terrain or to enter into dangerous weather threats respectively or in combination of them to achieve a significant pilot workload reduction.
The automatic avoidance maneuvers are a key element in the path to the flight automation in the presence of unexpected threats without the participation of the flight crew.
Currently avoidance maneuvers require the flight crew control in response to the TCAS, TAWS or WXR threats. Only TCAS automatic avoidance maneuvers are already available in the Airbus family, thus this project intends to assess an integrated solution that provides automation of avoidance maneuvers for all systems that currently provides alerts in response to unexpected external threats.
Aircraft safety systems (TCAS (including ADS-B), TAWS and WXR) with the addition of automatic flight control and automatic thrust will finally provide autonomous aircraft guidance in the presence of unexpected threats.

The goal of this topic is to deliver an innovate and affordable solution embedded in a single processing platform suitable for integration in different A/C platforms, namely, large passenger aircraft and regional aircraft with minimum integration activities.

The prototype will be demonstrated on ground up to TRL5.

The state of the art of similar technologies already implemented in Airbus Platforms such as, TGCAS, OANS, AP/TCAS Mode and EVS/SVS, provide improvements in pilot situational awareness (SA), but excepting the AP/TCAS mode, they do not provide guidance command to perform in automatic mode the needed maneuvers, the pilots have to execute them based on their skills, thus the goal of this call is **to provide maneuver automation**.

2. Scope of work

The 3 main streams composing the activity plan addressed in this topic are highlighted below.

T-1 Visual Recognition and Automatic Command for Takeoff, Approach and Airport Navigation

The partner has to explore and develop a visual recognition and **automatic command system** through visible and infra-red light spectrum EVS (EO/IR device) to provide the required redundancy to execute the take-off, final approach and airport navigation operations to supplement the guidance provided by the standard approach and airport navigation systems. To reduce the pilot workload the outcome of the image processing must be translated into automatic commands to the A/C keeping the pilot in the loop. The information will be displayed in the PFD or in an eye visor.

For this purpose Airbus Defence and Space (Airbus D&S) will provide the following inputs to the partner[16]:

1. A/C Operational Concept
2. High level system Requirements document
3. High level System Architecture

Based on the operational concept and system specification provided by Airbus D&S the partner activities will cover system detailed architecture, interface specification, system development, integration support to lab testing, global V&V and performance assessment.

The partner will select an EVS COTS HW, will define the detailed requirements and will design and deliver a field loadable SW for the image processing and guidance commands to be integrated in the housing hardware.

T-2 Automatic Avoidance Manoeuvers

The partner is invited to explore and develop an **automatic aircraft response** to the Terrain Awareness and Warning System (TAWS) and Weather Radar (WXR) warnings to avoid collision with other aircrafts, with the terrain or to enter into dangerous weather threats respectively or in combination of them.

The system will have to host the appropriate HW/SW to acquire the avionics parameter from the above systems, and the processing algorithms needed to determine the right command to perform the appropriate aircraft maneuvers to avoid collisions.

For this purpose Airbus D&S will provide the following inputs to the partner[17]:

1. A/C Operational Concept
2. High level system Requirements document
3. High level System Architecture

Based on the operational concept and system specification provided by Airbus D&S the partner activities will cover system detailed architecture, interface specification, system development, integration support to lab testing, global V&V and performance assessment.

The partner will deliver a field loadable SW to be integrated in the housing hardware.

T-3 Avionics Technologies Host System

The partner will deliver in an affordable and flexible way a housing hardware and base software system prototype to host and manage the interfaces of the functions developed in the LPA PT3 WP3.1.2 framework, in addition to the functions defined above.

For this purpose Airbus D&S will provide the following inputs to the partner[18]:

[16] These inputs intend to ensure the consistency of the topic outputs with the A/C reference defined for the Pilot Workload Reduction Functions demonstration and the Active Cockpit ground demonstrator. The topics is fully open to innovative concepts contributing to the flight automation goals as per described.

[17] refer to previous footnote

[18] refer to previous footnote

1. An interface requirements document. This system will also include the interfaces and processing power to host other future functions to decrease equipment cost and complexity and provide growth capability for 2025 SESAR requirements, including reverse (Undo) capability, while maintaining the current functions and interfaces of different A/C platforms. Thus a high level of commonality in terms of inputs outputs and functions is required.

2. A detailed design for a compatible & qualified computer case allowing minimum installation impact in the A/C.

In this activity the partner will define the concept design and the detailed requirements of the components composing the proposed architecture proposed as candidate solution and will perform the integration of the functions (SW) described above (visual recognition & command and automatic avoidance manoeuvres) onto physical HW prototypes manufactured according to the requirements. The partner is expected to include in the early stage of the design all the constraints related to certification aspects.

The partner will deliver the HW/SW prototype to the Topic manager and will support the integration phase the Active Cockpit until completion of the TRL-5 validation process as part of the project.

Partner(s) contribution can be summarised as follows for the whole activity:

1. Requirements definition at equipment and system level based upon requirements provided by Airbus D&S
2. Defining Image Recognition System and Automatic Avoidance Manoeuvers composed of an processing platform and different (as per technology) real time processing algorithms, based upon system architecture concept provided by the Airbus D&S
3. Building & testing prototypes (hardware and software) for concept validation, operational and performance verification on applicant facilities, interfacing with A/C systems models develop by the partner or to be provided by D&S
4. Support Airbus D&S during the integration, tests and validation of the prototypes on Airbus D&S test environment.

Main Tasks

Tasks		
Ref. No.	***Title – Description***	***Due Date***
Task 1	**Project Development Plan –** A detailed project plan, including WBS, scope & schedule shall be established.	T0+4
Task 2	**Definition of requirements** - Requirements shall be defined at System and equipment level	T0+7
Task 3	**Validation & verification plan -** For each requirement a proposed means of compliance shall be defined for the validation & verification process.	T0+16
Task 4	**System Concept definition** – System and components concept shall be defined to support the defined requirements a) State of the art and review of available technologies. b) Trade Off and selection of potential solution	T0+20

Tasks		
Ref. No.	***Title – Description***	***Due Date***
Task 5	**System Validation and Verification –** The design solution and final product shall be validated, refined and verified: a) Building of prototypes, system and associated test rig for V&V b) Validation and Verification test and analysis of the selected solution. c) Support to Airbus D&S during the integration, tests and validation of the prototypes on Airbus D&S simulator. The expected maturity level for the final prototype is TRL5.	T0+34
Task 6	**Final Report –** All results shall be formalized in the final report.	T0+36

3. Major Deliverables / Milestones and schedule (with respect to the 3 main streams T-1, T-2 and T-3)

		Deliverables		
	nº	***Title – Description***	***Type***	***Due Date***
T-1	D1.1	Conceptual solution description including selected EVS (system architecture, algorithms, operational use)	(D) Document	T0+4
	D1.2	Solution capability analysis	(D) Document	T0+6
	D1.3	Detailed solution description	(R) Acceptance Document	T0+12
	D1.4	SW solution ready for verification + EVS HW	(SW&HW) + Acceptance Document	T0+18
T-2	D2.1	Conceptual solution description	(D) Document	T0+4
	D2.2	Solution capability analysis	(D) Document	T0+6
	D2.3	Detailed solution description	(R) Acceptance Document	T0+12
	D2.4	SW solution ready for verification	(SW) + Acceptance Document	T0+18
T-3	D3.1	Conceptual solution description	(D) Document	T0 + 9
	D3.2	Solution capability analysis	(D) Document	T0 + 6
	D3.3	Detailed solution description	(R) Acceptance Document	T0+12
	D3.4	Avionic technology hosting prototype for validation (TRL4) and System Spec	HW&SW Delivery+partial acceptance	T0+30
	D3.5	System Verification (verification test and analysis of the of the solution)	(R) Acceptance Document	T0+34
	D3.6	Final Report for Integration Validation (TRL5)	(HW & SW, R) Acceptance Document	T0 +36

Milestones		
Ref. No.	***Title – Description***	***Due Date***
M0	KOM: Kick of meeting	T0
M1	PDR: Supplier provides a preliminary solution agreed with Call requester	T0+6
M2	CDR: Supplier provides a detailed design agreed with Call requester and frozen	T0+12
M4	Decision gate for Integration Validation (TRL4) Test dry run and fine tuning of the solutions to reach a satisfactory solution performance	T0+29
M5	Decision gate for Integration Validation (TRL5)	T0+36

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

- Experience in development of aeronautical systems, both HW and SW
- Experience in aeronautical interfaces (ARINC429, ARINC629, MIL-STD-1553, AFDX)
- Experience in ARINC 653 / Integrated Modular Avionics (IMA)
- Experience in EO/IR systems, Flight Control Systems, and Surveillance Systems
- Experience in Systems Simulation and Stimulation
- Experience in Test Rig environments
- ISO 9100 certification
- Experience in Equipment qualification with EASA/FAA authorities

An Implementation agreement will be proposed to manage the IPR and the relation between the Topic manager and the Applicant(s).

5. Abbreviations

- TCAS Traffic Collision Avoidance System
- TAWS Terrain Awareness and Warning System and
- WXR Weather Radar
- CPDLC Controller–pilot data link communications
- IMA Integrated Modular Avionics
- COTS Commercial Off The Shelf
- EVS Enhanced Vision System

XVI. Multimodal HMI development tools

Type of action (RIA or IA)	IA		
Programme Area	LPA IADP - Platform 3		
Joint Technical Programme (JTP) Ref.	WP3.1.4.6		
Indicative Funding Topic Value (in k€)	600		
Topic Leader	Honeywell	Type of Agreement	Implementation Agreement
Duration of the action (in Months)	24	Indicative Start Date[19]	Q1 2018

Topic Identification code	Topic Title
JTI-CS2-2017-CfP06-LPA-03-11	**Multimodal HMI development tools**
Short description	
This topic aims to develop prototyping and development tools allowing HMI Designers to specify and validate Multimodal HMI (legacy controls, touch, voice, eye etc). In particular, the toolset shall allow HMI designers to specify the flight deck configuration and allocate modalities to HMI elements.	

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

1. Background

European Aerospace OEMs have an objective to reduce development cycles, to control time to market and to differentiate through an innovative and unique flight deck design. Human Machine Interface (HMI) model-based prototyping and development tools are an essential enabler to achieve this objective, by providing the OEM with the autonomy to prototype, evaluate and formally specify the HMI graphics Look & Feel and logics requirements. Often, those tools call upon HMI standards such as ARINC 661 in order to guarantee tools suite sustainability, interoperability between the OEM design environment and the suppliers Control & Display System development environment hence supporting parallel design of the flight deck concept, of the CDS and of the User Applications by different parties.
Future European flight decks will depart from the current design paradigms (cursor-control) by introducing the so-called post-WIMP HMI (Windows Icons Menus Pointing Human Machine Interface), introducing new interaction modalities such as direct touch screens, voice command or gaze tracking. Equally important, the flight deck configuration – the way displays are structured in windows, layers and how these can be reconfigured based on crew needs and system availability – is going to be much more flexible and adaptive. Those novel and innovative flight deck concepts are being defined as part of the Clean Sky 2 project focused on Business Aviation running in the Platform 3.
While HMI model-based processes & tools are available today (some of them compliant with ARINC 661), existing tools typically do not offer the capability to specify the flight deck configuration (or "windowing") and the interaction philosophy, that is the allocation of interaction modalities to windows, layers or widgets, as well as the behavior of these objects when activated via touch, voice or gaze control modalities. In the perspective of the Future European Flight Decks, this constitutes a major gap in the prototyping and specification chain for the OEM.
The objective of this topic is to bridge this gap by providing a turnkey HMI prototyping and formal specification capability for the HMI Designer (could be the OEM, the Displays integrator or the third party User Applications developers), taking into account the characteristics and needs of the future multimodal flight deck.

2. Scope of work

This topic will address the 2 crucial tool capabilities that will be used in complement / as add-ons to existing HMI model-based development tool suites.
Note: the list of tools features is for indication and is not exhaustive, as there will be an initial project phase when tools requirements will be refined with the Partner.

1. Support for innovative modalities and multimodal control

This capability will allow the HMI Designer to:
- Allocate interaction modalities at window, layer, or widget level
- Specify if modalities can be used exclusively or in combination
- Specify the actions that can be performed by application/subsystem
- Specify required reliability for triggering an action (in relation with the action criticality)
- Specify if the action is performed exclusively by the application or should/can be performed in cooperation with other applications
- Specify multi-application commands – i.e. triggering actions to multiple applications that cooperate to accomplish the desired action)
- For modalities combination, specify inputs fusion parameters

2. Flight Deck configuration / Window management

This capability will allow the HMI Designer to:
- Specify the number of displays, max windows per display, max layers per window etc
- Specify the possible sizes and positions of the windows
- Specify how the different views are positioned on the displays, according to HMI cockpit configuration logics - based on phase of flight, aircraft status, crew commands, functional states, crew states, displays fault modes

The provided tools should meet the following list of requirements:
- Model-based, and preferably ruled-based with the end objective to be qualified per DO-330/ED-215 and allow for V&V credit
- Generating code or configuration files
- Possibility to use as an extension to existing HMI development tool suites, through a standard interface
- Compatible with ARINC 661 as far as possible, in particular Supplement 6
- Compatible with the selected software architecture for Multimodal Interaction Management and Flight Deck configuration management
- Support of multimodal fusion and fission principles
- Tools shall support requirements validation by the HMI Designer at a desktop station
- Intuitive and easy-to-use tools that do not require extensive IT background of the user

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 0	**Project Management** Support periodic status meetings with the DECK leader. Provide progress briefs	T0 – T0 +24 Mo
Task 1	**Toolset specification – capabilities & integration with Displays software** a/ Contribute to refining the tools requirements with the DECK project leader and Dassault Aviation, based on a list of use cases b/ Work with the DECK project leader to define expected tools outputs (configuration file, software code) and how they integrate with the Cockpit Manager and Multimodal Interaction Manager software modules within the anticipated Displays software architecture for the Future Multimodal Flight Deck	T0 – T0+6 Mo
Task 2	**Tool capabilities development - initial** Prototype the tools and perform pre-integration with a selection of existing HMI model-based development tools	T0+6 – T0+12 Mo
Task 3	**Evaluation support - initial** Support the DECK leader in the tools evaluation – tools will be used to implement HMI concepts and prototypes developed by the DECK leader in collaboration with Dassault Aviation. Populate a log of defects and improvements requests.	T0+12 – T0+18 Mo
Task 4	**Tool capabilities development - update** Perform updates of the tools based on the observations from the tools evaluation phase	T0+18 – T0+21 Mo
Task 5	**Evaluation support - update** Support the DECK leader in the tools update evaluation	T0+21 – T0+24 Mo

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	Tools requirements specification[20]	R	T0+6 months
D2	Framework version 1	D	T0+12 months
D3	Evaluation log version 1	R	T0+18 months
D4	Framework version 1	D	T0+21 months
D5	Evaluation log 2	R	T0+24 months

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	**Phase 1 completion** Initial framework delivered and evaluated	M	T0+18 months
M2	**Phase 2 completion** Updated framework delivered and evaluated	M	T0+24 months

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

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

The successful partner must exhibit the following skills, capabilities and experience:
a. Skills for and experience in developing in-house formal, model-based HMI development tools
b. Preferably with a track record of tools in-service in Aerospace or similar safety-critical industry
c. Expert knowledge of ARINC 661 standard and its anticipated evolutions
d. Expert knowledge of Aerospace software development processes, DO178C
e. Experience in tools qualification, DO-330/ED-215
f. Experience in collaboration with Aerospace OEMS and Avionics suppliers
g. Experience in innovative modalities (touchscreen, voice control etc)

Miscellaneous requirements:
a. As the partner shall interface/integrate the tool capabilities as part of existing tool suites, the partner shall provide free of charge tools licenses to the DECK leader for the duration of the project in order to evaluate the integration of the new capabilities within the larger tool suite and how the end-to-end tool suite meets the needs of the HMI Designer.
b. Plan for on-site support at the DECK leader facility in Brno

[20] The partner is a contributor to the document

XVII. <u>High Density Electrical Connectors</u>

Type of action (RIA or IA)	IA		
Programme Area	LPA		
Joint Technical Programme (JTP) Ref.	WP 3.2.3 Cockpit Utility Management System - UBBICK		
Indicative Funding Topic Value (in k€)	500		
Topic Leader	Zodiac Aerospace	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date21**	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-LPA-03-12	**High Density Electrical Connectors**
Short description	
The topic aims at defining new type of connectors addressing Modular, low cost and high density connection for avionics application. These new connectors will be designed, manufactured and tested onto a Remote Data Power Cabined studied in the frame of the Platform 3 of LPA IADP. The applicant will benefit of this topic to prepare a future standard of connectors.	

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

1. Background

Today, Aircraft computer systems are mostly federated (i.e. dedicated to one system) and thus have a limited number of physical interfaces (only those that are needed for a given system, including spare and growth). They use standard packaging and connectors, in a low connection density environment. Last Integrated Modular Avionic Line Replaceable Module generation, that allows for multiple systems to host their functions onto the same shared computer system, have been designed considering the actual characteristics of the system they are intended to host. Their packaging and connectors are also standard (mainly ARINC600), and they typically manage a higher density than federated computers.

With the processing power to surface ratio increasing in modern computer systems, it is expected that future IMA type computers will be able to handle an increasing number of physical I/O within a constant installation envelop, and that their design is increasingly generic and user system independent. Also, these I/O are expected to be of different nature (discrete, analog, data, power, optical, etc), while coexisting within the same electronic board.
A previous European research projects called PRIMAE have already started studying the subject, and have provided results confirming these trends.

In this context, high density connection solutions are expected to provide low cost, standard products, addressing several topics yet unexplored by the aircraft industry, like direct connection of rackable blades (and associated insertion forces), aircraft cabling & system installation ergonomy, and variable environmental constraints.

The objective of this topic is to support the development of high physical I/O density computer systems, through a standard, low cost and modular interface approach, that can be broadly deployed in the A/C systems industry. The proposed approach by the awarded applicant(s) will target the elaboration of a new connector standard.
This element is a necessary enabler to achieve the RDPC system demonstration and to meet the maturity objectives pursued by Zodiac Aerotechnics at completion of LPA activities.

2. Scope of work

The applicant(s) are expected to contribute to Zodiac Aerotechnics objectives trhough the interaction with the topic manager leading the activity.

The applicant(s) shall propose a fully compatible set of physical interface solutions (connectors), based on the installation constraints, which will be detailed at the beginning of the project.

With an extensive experience on A/C systems interfacing, the applicant(s) will propose a harnessing approach that addresses the key roadblocks of high connection density systems installation: operator access ergonomy (installation and maintenance of both the system and the A/C wiring), electronic boards insertion and extraction forces, and variable exposure to electro-magnetic effects.

Furthermore the interfaces shall comply with the following general requirements:

- **Modular:** being able to host different types of interfaces (power, fequency) within a constant installation envelop. Being able to build the connection interfaces based on reusable and adaptable building blocks

- **Standard:** based on industry standard building blocks. Furthermore, the applicant(s) shall define a roadmap for standardization of the building blocks developed within this topic.
- **Design to cost:** target production cost of the overall connection solution shall be 60% below current EN4165 based solution.
- **Ergonomy:** efficient connectors installation operation during electronic boards production. Efficient installation of connectors on A/C harness side, as well as of system structure on the Aircfraft.
- **Connection points density:** it shall be possible to host at least 210 connection points on one 6UE format electronic board. It shall be possible to rack/unrack a board at least 500 times without using any tool.

Based on requirements provided by the topic manager resulting from airframes constraints analysis, the project will be carried out in three phases: state of the art analysis, product definition, and parts development.
In the first phase, the applicant(s) will perform a market survey to determine what existing standard technologies could be used as building blocks for the system's physical interface implementation.
Based on this analysis, the applicant(s) will propose a specification and a development roadmap to define and produce those new building blocks necessary to the different system's use cases.
Finally, the parts will be integrated to the system's equipment, and environmental tests will be carried out. The applicant(s) will analyse the test results and update the part's design, if needed. As the new developped connectors are expected to be standardized, the results shall be disseminated to the parties contributing to the standardisation activity applicant(s). The targeted maturity at completion is TRL6.
All the contributing parties required/ involved in the elaboration of a new connector standard will be listed and the path to the elaboration of such a standard will be presented in the proposal (leadtime). The exploitation of results arising from this project will be clearly described.
The activities will take place within LPA IADP Platofrm 3 Work Package 3.2.3 "Cockpit Utility Management System - UBBICK", and will be split into 7 major tasks:

Tasks		
Ref. No.	**Title – Description**	**Due Date**
Task 1	**State of the art analysis** – Based on Cockpit Utility Management System physical interface requirements, perform cost and risks (technical, cost, certification) analysis. Present current trends	03-2018
Task 2	**Define development orientations** – Based on results from Task 1, conduct a series of WS to agree on a way forward and strategy, between the selected partners and the topic manager.	05-2018
Task 3	**Specify Cockpit Utility Management System physical interface** – Based on results from Task 2, the selected partners will work together on a specification that formalizes the system's physical interface definition.	07-2018
Task 4	**Develop/adapt/produce Cockpit Utility Management System physical interface elements** – system's prototypes for environmental tests will be developed using the physical interfaces obtained from this task. The system will be composed of 16 6UE electronic boards + respective harnessing elements.	12-2018
Task 5	**Perform characterization environmental tests** – Perform environmental characterization of prototypes.	07-2019
Task 6	**Analyse and integrate Cockpit Utility Management System environmental tests results** – Integrate results into the Cockpit Utility Management System physical interface design.	12-2019

Tasks		
Ref. No.	**Title – Description**	**Due Date**
Task 7	**Final Report** – Formalize the project's results and provide a status for the associated products.	12-2019

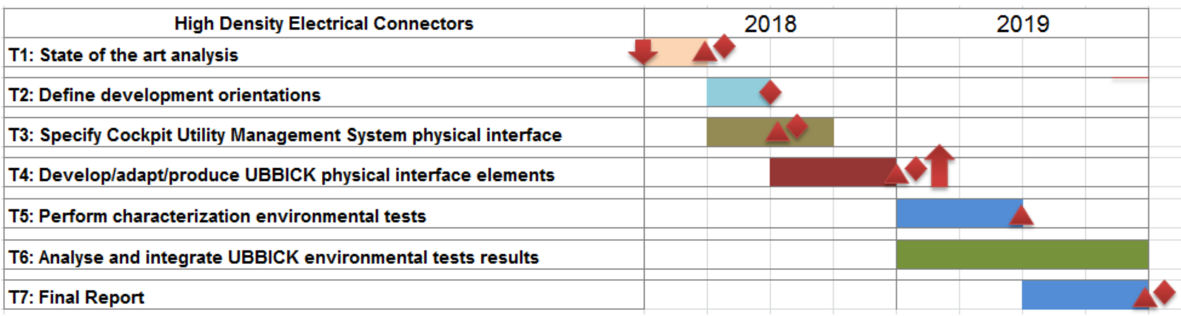
3. Major deliverables/ Milestones and schedule (estimate)

The following list of deliverables and milestones are proposed.

Deliverables			
Ref. No.	**Title - Description**	**Type**	**Due Date**
D.1	A/C Computer Systems physical interfaces State of the Art description	Report	03-2018
D.2	Cockpit Utility Management System physical interfaces specification	Document	06-2018
D.3	Cockpit Utility Management System physical interface elements prototypes	HW	12-2018
D.4	Environmental Tests Results	Document	07-2019
D.5	Final Report	Document	12-2019

Milestones			
Ref. No.	**Title - Description**	**Type**	**Due Date**
M.1	State of the Art review	Review Meeting	03-2018
M.2	Cockpit Utility Management System physical interfaces plan review	Review Meeting	05-2018
M.3	Environmental Test readiness review	Review Meeting	12-2018
M.4	Results Assessment Review	Review Meeting	12-2019

Schedule



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

- Background and Expertise as a provider of connectors and complete connection solutions for the A/C industry.
- Strong knowledge of environmental constraints applicable to Aircraft systems, in particular those related to electro-magnetic effects.
- Strong knowledge on electrical, wiring and installation aspects of aircraft systems.
- Innovation driven. Internal Research & Technology roadmap to be provided.
- All activities associated to this topic shall be carried out inside the UE.
- Background and expertise on product standardization.

2. Clean Sky 2 – Regional Aircraft IADP

I. <u>Innovative Low Power De-Icing System</u>

Type of action (RIA or IA)	RIA		
Programme Area	REG		
Joint Technical Programme (JTP) Ref.	WP 2.3.1 WIPS Low Power		
Indicative Funding Topic Value (in k€)	1200		
Topic Leader	Leonardo Aircraft	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[22]	Q1 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CFP06-REG-01-09	**Innovative Low Power De-Icing System**
Short description	
To design, develop and manufacture a demonstrator of Low Power De-Icing System, including the leading edge wing section where it will be installed. The demonstrator will be tested up to TRL 5 in a IWT (not part of this Topic); the Applicant shall also assure the support to testing activity for system performance validation. The system design will be based on the icing requirement of the regional aircraft wing to be provided by the Topic Manager. An Electro-Thermal de-ice solution would be preferred but the Applicant can propose alternative solutions.	

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

1. Background

The Regional aircraft, expecially the turboprop powered ones, suffer of power availability for onboard systems application. Aircraft De-Icing System is one of the most power demanding onboard systems.
Within Clean Sky 1, activities related to technologies development and demostration of a mixed low power de-icing system (electro-thermal/electro-expulsive) have been performed but the level of size, power and weight resulted not feasible for Regional aircraft where space and installation constraints are much more stringent.
All the above, together with the need to increase engine efficency readucing the specific fuel consumption, put the need for aircraft European manufacturer to have a safe and reliable low power deicing system not using pneumatic source.
The intent of this call is to involve a european partner in researching, designing, developing and testing up to TRL5 a low power de-icing system suitable in terms of power, weight, space envelope and cost for the European Regional aircraft transportation.
Low Power De-Icing System suitable for Regional Aircraft is part of REG IADP WP 2.3 which is dedicated to Energy Optimized Regional Aircraft activities.
In details the objectives are:

- To optimize a low power system architecture suitable for Regional configuration
- To develop novel integration concepts of the wing ice protection system within a Regional Aircraft leading edge structure to optimize weight saving while ensuring manufacturing quality, reparability and maintainability.
- To demonstrate maturity of the technologies at TRL5 level through demonstrations in a representative environment

The topic in objects aims at study and develop innovative Wing De-icing technologies based on electrically-powered system. The Electro-Thermal de-ice solution would be preferred but the Applicant can propose alternative low power solutions, provided that the proposal shows compliance with Ice Protection safety and performance aspect, and optimizes, with respect to an electrothermal solution, weight, space allocation, integratibility in the wing, reliability and maintainability of the system, in addition to the electrical power.
System performance verification will be pursued by means of Icing Wing Tunnel test campaign (not part of this topic), in order to contribute to reach the TRL5 for the selected IPS technologies.

2. Scope of work

The intent of this call is to select a Partner for the Design, Development and support Testing in a IWT a Thermal low power de-icing system, or in alternative, a low power de-ice solution.
More in detail, the scopes of the topic are:

1. To define system architecture, components sizing and control logic of a Low Power De-Icing System for the regional aircraft.
2. To design, develop and manufacture a demonstrator of Low Power De-Icing System, including the leading edge wing section where it will be installed: “smart leading edge” with embedded WIPS and Control Box.

The first objectives of the present topic is the definition of the architecture, the components sizing and the control logic of a Low Power De-Icing System based on the icing requirement, electrical characteristics and space allocation of the Regional aircraft wing. System shall be designed so to optimize icing/de-icing cycles in order to optimize electrical power consumption.
Main issues include definition of the ice protection performance and requirements such as residual ice limits

and allowable inter-cycle ice to have suitable handling qualities, definition of protected surface and their extent, ice protection cycles optimization.
WIPS shall be compliant with Civil Certification requirements of aircraft Ice Protection, covering maximum continuous and intermittent maximum conditions, the behaviour in the Super-Cooled Large Droplets condition shall also be considered as per CS 25.1420 Amdt 16.
With reference to the IWT campaign to be performed, a demonstrator of Low Power De-Icing System, including the leading edge wing section where it will be installed and control box for test execution, shall be provided by the Applicant. The demonstrator will be a representative portion of the complete system. The Applicant shall be in charge of test article and tooling manufacturing, and of the IWT test support in terms of procedure definition and test execution and data analysis support. The selected Partner will work in close conjuction with the Topic Manager.
In the following paragraphs a general complete description of the project is reported. The description of the main topics are related to WP 2.3.1 "Low Power WIPS".

Work requested to the Partner

The main tasks of the project under CfP are summarized in the following table:

Ref. No.	*Title - Description*	*Due Date*
T1	Ice Impingement Analysis for system requirements definition	T0+9
T2	Definition of system architecture and sizing of complete ice protection system for Regional Aircraft (Preliminary Design)	T0+12
T3	System detailed design	T0+24
T4	IPS Demonstrator components design, development, testing and delivery for IWT	T0+32
T5	Support IPS IWT demonstration and assessment	T0+36

Task 1: Ice Impingement Analysis for system requirements definition

Based on TLARS and technological targets, Topic Manager will define the wing profile. Based on defined wing profile, the call partner will perform and share with Topic Mamager analysis for impingement limits definition and ice accretion results.
The choice of performing a 2D or 3D analysis is left to the the selected partner based on its experience on icing analysis.
Studies performed by applicant shall target the system sizing versus ice certification requirements and integration studies. Results shall allow the evaluation of wing de-icing system performances in both Appendix C and O. Specific phenomena linked to Appendix O conditions shall be analyzed and taken into consideration to define areas to be protected and electrical power required.
The main activities foreseen by this task are:

- Ice impingement and shape analysis for low power de-icing system requirement definition
- A preliminary system specification

Laminarity concept for outoard wing section will be explored in a different WP. Requirements will be shared with the selected Partner, to allow an harmonization of ice architecture with aerodynamic constraints.

Task 2 : Definition of system architecture and sizing of complete ice protection system for Regional Aircraft (Preliminary Design)

The partner shall perform the preliminary design of the low power de-icing system based on the requirements set by the Topic Manager in HLTR and on ice impingement analysis results, defining system architecture and all necessary components.

Low Power architecture definition shall be conducted for a wing in order to:

- Define the mat arrangement in an iterative process with the structural, aerodynamic and system layout trade-off
- Provide the system electrical power consumption for a wing for the system sizing
- Provide the system definition including selected voltage, EMI protections, failure modes,
- wiring definition, volumes, weight and costs.

Proposed system architecture shall be of a de-icing type, in order to optimize electrical power consumption, the anti-icing portion of the system shall be eliminated.

Proposed architecture shall assure de-icing capability in compliance with certification and safety requirements and will optimize: electrical power consumption; weight; space allocation and integrability; reliability and maintainability. The architecture shall account for the interaction between the system and the structure (thermal fatigue, thermal differential expansion, transient temperature mapping, ageing of the material due to system operation).

The architecture shall account morphing structure requirements and the link with WP 2.1.2 will be pursued with the perspective of an additional constraints vs thermal de-icing optimized solution.

The architecture shall account for the space allocation of the Regional A/C. The precise relevant dimensions, such as the length of the root chord and tip chord, relative (% chord) front spar position and height, will be provided to the winning applicant at the beginning of the project.

Moreover, space allocation of the system shall be minimized in order to allow installation of other A/C systems.

Wing structure will be in composite.Electrical interface requirements for the system will be provided to the selected Candidate. Furthermore, the concept shall address reparability and maintainability keeping in mind that the target is to propose a solutions at least as convenient as presently in-service systems & structure.The call partner will provide all the information related to the chosen architecture, in terms of (at least):

- System detailed description
- Wing De-Icing Performance
- Residual Ice
- De-icing Cycle hypothesis
- Weight and dimensions for the system and leading edge structure
- Structural fatigue analysis compliance
- Ice fracture criteria
- Acoustic properties
- Installation characteristics
- Bird strike compliance
- Integration study
- Maintenance
- System Failure
- Interchangeability
- Certification and safety aspects evaluation

This task ends with Preliminary Design Review (PDR).

Task 3:System Detailed Design

The Partner shall perform the Detailed Design of the Low Power System. In particular shall:

- Perform the detailed design of the all system components/equipment
- Provide 2D drawings of the all components/equipment
- Update weight report
- Finalize the Power & Electrical Load Analysis
- Provide a preliminary reduced scale IWT Plan & Procedure
- Test Article Mechanical design

All the technical informations provided during the preliminary design phase shall be updated.
This task ends with Critical Design Review CDR

Task 4: IPS Demonstrator components design, development, testing and delivery for IWT

The Partner shall be responsible for the Test Article manufacturing and for the definition of the IWT test planning and procedure to demonstrate the effectiveness of the Low Power De-Icing System.
Test Article including Low Power WIPS component
A demonstrator of Low Power De-Icing System, including the leading edge wing section where it will be installed and control box for test execution shall be provided by the Applicant. The reference geometry profile for the wing is the Regional profile. Test article size as section of wing will be selected as the most significant from aerodynamic and systemistic point of view (in agreement with maximum chamber size permitting). Topic Manager will provide the detailed sizing in terms of spanwise and chordwise of the test article.
Orientatively the wing section to be tested shall be the wing outboard with the following size:

- o Chord size : 1500 mm
- o Spanwise size: depending on IWT test chamber size

Test article section shall be scale 1:1; a 2D model is sufficient.
Topic Manager will generate the preliminary a/c setting requirements vs icing conditions accretions expressed in terms of: incidence; mach; altitude; flight phase; local angle of attack; local sweep angle; flap settings. With reference to the test article, the selected Candidate shall define:

- IPS configuration for test (mats and their distribution on the protected surface, power electronics).
- Lab test Instrumentation and IWT instrumentation specification (to be agreed with Topic Manager).
- Control logic for test. The partner shall provide robust control laws and monitoring means for the test execution. Based on provided control logic, it shall be possible to investigate spanwise several functional mode (e.g. D/I cycle activation), and power regulation as function of ice accretion or chordwise position. Strategy of control shall be defined, in cooperation with the Topic Manager. Monitoring shall be ensured to protect wing structure against overheat and low power as well.
- Detailed Planning and Procedure for the IWT.

With reference to the test article, the selected Candidate shall provide:

- Test Article structure integrated with thermal mats (or de-icing device). Test Article (Wing section) shall be made of composite material.
- Control Unit and Control Panel.
- The necessary tooling related to test article.

With reference to the Lab Test Instrumentation for IWT, the parameters to be monitored shall be agreed with Topic Manager. Any component or subsystem proposed for the demonstration will be fully representative of the section of Regional Aircraft selected by Topic Manager.
The model subjected to the test activity will be equipped with sensors for the measurement of airfoil skin deformation induced by IPS system device.
Test execution and acquisition of wind tunnel parameters during tests will be under the selected candidate's responsibility.

Test Article Qualification:
The test article shall be qualified so to operate in IWT environment during test execution reducing the risk of failures or malfunction which could compromise the test campaign. Test article specification will be provided to the selected Candidate detailing qualification requirements that the integrated smart leading edge shall comply with.
The applicable requirements will cover:

- Functional Performance

Functional test intended to assure the WIPS will correctly operate in IWT operational environment.

- Environmental Requirements

In order to allow test execution without failures or malfunctions, the smart leading edge test article including WIPS low power device shall be qualified to environmental requirements to be mutually agreed (for instance: temperature; temperature variation; magnetic effect; power input; voltage spike; electrostatic discharge; emission of radio frequency energy).
Acceptance criteria of the test article will be mutually agreed with the partner.
Detailed Electrical interface requirements for the test article will be provided as an input in the early stage of the project.

Input documentation for IPS demonstrator:
The selected Candidate will rely on detailed supporting information generated in the framework of WP 2.3.1 activities. The Test Article Specification will include:

- Interface Control Document for electrical interface /mechanical connections
- WIPS requirements
- Test article structural requirements
- Test article overall geometry (CAD models)
- Qualification documents applicable to the demonstrator
- Icing case condition selection (altitude, Mach, flight phase)

With activity included inside the Task 4, TRL 4 will be reached.

Task 5: Support IPS IWT demonstration and assessment

The IWT test campaign will be finalised to testing the system integrated into the wing section sample in a range of operating points covering the critical condition for the RA, in terms of speed, altitude, MVD and LWC. The selected call partner, in concurrence with Topic Manager, will prepare an IWT Test Program oriented to IWT tets execution. The ice wind tunnel test will be performed in the context of a separate complementary activity (not part of this call). Topic Manager will require some specific test conditions for icing tests and approve the icing tunnel test program. Topic Manager and CfP partner will participate to the icing tests.

The results of IWT campaign shall be analysed and all the tested configurations shall be compared in order to evaluate system performance. After IWT tets execution on representative wing section, complete system performance analysis shall be updated in order to take into account the test results.

The Partner shall be responsible for running the testing in IWT on the Test Article for performance demonstration at the design points agreed with the Topic Manager. Maturity of the proposed concept, which is one of the main drivers, has to be shown. In this task the partner shall be responsible for:

- Installing the demonstrator and instrumentation in the IWT
- Record all the data after running in IWT
- Write the IWT test plan and IWT test report
- Update performance document for the complete system based on test results

Customer Support

The Partner shall guarantee and repair the delivered items in case of items defects or damages

3. Major deliverables/ Milestones and schedule (estimate)

The applicant is requested to provide technical data for the proposed activities. Applicant activity start time is corresponding to T0 approximately on January 2018. Relevant CfP involvement is requested from T0 to T0+36 Months. Following table contains a preliminary list of all the major deliverable.

Data Requirement List			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Ice Impingement analysis	R	T0+3
D2	Preliminary System Specification & architecture description	R	T0+9
D3	Preliminary Control Logic functional description	R	T0+12
D4	System ICD	R	T0+12
D5	Weight Report	R	T0+12
D6	Preliminary Electrical Power Budget	R	T0+12
D7	Equipment/Components 3D Models	D	T0+12
D8	Structural integration demonstration	R	T0+12
D9	FMEA & SSA	R	T0+12
D10	Residual ice shape analysis	R	T0+12
D11	Preliminary Ice Protection System performance report	R	T0+12
D12	System final specification and architecture description	R	T0+24
D13	Updated Ice Protection System Performance Report	R	T0+24
D14	Final Control Logic Functional Description	R	T0+24
D15	Component/Equipment 2D drawings	D	T0+24
D16	Final Electrical power budget	R	T0+24
D17	Update Weight Report	R	T0+24
D18	IWT preliminary Planning and Procedure	R	T0+24
D19	Test article Drawings(3D & 2D)	D	T0+24
D20	Test Article description comprising test article control logic	R	T0+24

Data Requirement List			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D21	System demonstrator hardware to support test campaigns(System LRU + Leading edge structure)	D	T0+32
D22	Test article, control box and tooling availability	D	T0+32
D23	IWT instrumentation	D	T0+32
D24	IWT Planning and Procedure	R	T0+32
D25	Environmental & Endurance Test report	R	T0+32
D26	IWT Report	R	T0+36
D27	Final Ice Protection System Performance Report	R	T0+36

Note on hardware deliverables:

The Partner is expected to deliver all hardware and instrumentation necessary for the IWT demonstrations. Dedicated testing have to be addressed for other topics (Environmental, endurance testing to be achieved to get data about new design of ice protection devices).
It is not planned to perform flight tests as part of the project.
Note on Meeting and review during development:
Progress meeting shall be periodically planned between the parts during all development phases to evaluate and agree on requirements and results assessments.
Technical meeting shall take place in order to discuss in details specific technical points
Review meeting shall materialize the development steps and to state if all the works and documents foreseen for these review have been performed and are acceptable.
Management meeting shall be periodically planned during the development phases to advancements and project management issues.

Milestones			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Preliminary System Specification	R	T0+9
M2	PDR	RM	T0+12
M3	CDR	RM	T0+24
M4	IPS Demonstrator components design, development, testing and delivery for IWT	D	T0+32
M5	IWT & Test campaign report	R	T0+36

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

The applicant shall have knowledge of the aeronautic standards and ice protection certification and safety requirements. In addition the applicant shall have appropriate tools required to optimize Electro-Thermal power consumption in icing condition and provide associated system architecture definition.
Applicant shall show a strong experience in the following fields:

- Proven experience in the design and development of advanced technologies in the field of Anti-icing and De-icing Systems
- Numerical tools availability to assess thermal performance in Appendix C and O conditions
- Numerical tools availability to asses structure resistance under different kinds of steady and

transient loads (thermal, mechanical, impact)

- Validation of numerical tools against previously performed test campaigns (icing wind tunnel, structural testing, impacts)
- Capability to evaluate interaction between thermal and mechanical loads
- Proven experience in advanced composite structure manufacturing and assembly into a complete leading edge structure. Experience in incorporating ice protection devices inside leading edge structure
- Good experience and knowledge of aircraft icing issues
- Proven experience in international R&T projects cooperating with industrial partners, institutions, technology centers, universities,
- Quality and Risk management capabilities demonstrated through international R&T projects and/or industrial environment
- Proven experience in the use of design, analysis and configuration management tools of the aeronautical industry
- IWT test rig experience
- Proven IWT test running experience
- Instrumentation data acquisition, recording and monitoring

Applicant should demonstrate experience in preparation and conduction of icing wind tunnel test

HLTR

A set of High Level Technical Requirements (HLTR) for Low Power De-Icing System will be provided by the Topic Manager and negotiated with the selected Partner, in line with the objectives set by the Topic Manager.

5. Abbreviations

CAD	Computer Aided Design
CS2	Clean Sky 2
CP	Core Partner
D&M	Design & Manufacturing
REG IADP	Regional Integrated Aircraft Demonstration Platform
TLAR	Top Level Aircraft Requirements
IPS	Ice Protection System
IWT	Ice Wind Tunnel
HLTR	High Level Technical Requirements
PDR	Preliminary Design Review
CDR	Critical Design Review

II. E2-EM Supervisor and Control Algorithms

Type of action (RIA or IA)	RIA		
Programme Area	REG		
Joint Technical Programme (JTP) Ref.	WP 2.3.4 Advanced Electrical Power Generation & Distribution System		
Indicative Funding Topic Value (in k€)	800		
Topic Leader	Leonardo Aircraft	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[23]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CFP06-REG-01-10	**E2-EM Supervisor and Control Algorithms**
Short description	
Centralized smart supervisory control for Enhanced Electrical Energy Management (E^2-EM) strategy. Design, simulation, development, manufacturing, testing and integration of a controller embedding control logics for the innovative electrical distribution enabling technologies to be ground tested on the Regional A/C Iron Bird Demonstrator at Topic Manager lab facilities.	

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

1. <u>Background</u>

In the frame of a future Regional Aircraft, the Advanced Electrical Power Generation & Distribution System (A-EPGDS) technology will focus on the design and development of an innovative highly decentralized, modular and flexible "smart-grid" based electrical distribution network with solid state-based secondary distribution modules. In addition, the Electrical Power Distribution System (EPDS) will be equipped with so-called Enhanced Electrical Energy Management (E2-EM) functionalities. TRL 5 validation of the EPDS key elements are expected to be performed on Regional Iron Bird on-ground demonstrator.

The Enhanced Electrical Energy Management firstly aims to reduce or even delete the overload capabilities of main electrical generators and thus saving weight and volume for machines integration onto a Regional A/C future platform, as well as to reduce the generators failure rate by preserving their electrical capabilities.

Additionally to what already investigated and validated within CS1 Project, the E2-EM will also introduce utilization of local supercapacitors used as energy buffers during high and rapid transitory energy requests from some critical loads (e.g., flight control system or landing gear electro-mechanical actuators, EMAs). However, electrical energy management basic concepts, as already studied in the frame of CS1 Project (i.e. voltage chopping to some selected variable-power loads by means of SSPC devices), shall be also further explored and refined.

This CfP mainly aims to design, develop, manufacture, test and integrate (at Iron Bird on-ground facilities) a Centralized Smart Supervisory high level "hardware" controller embedding the E2-EM control logics and able to be interfaced with the lower level controllers of the "Smart-Grid System" and the "Advanced Energy Storage and Regeneration System" (to be provided by other already launched Projects) in order to implement an optimal sharing of the available electrical power on-board during failures and/or overload conditions, thus not relying on main generators overload capabilities.

a) Smart-Grid Network

The EPDS for Regional A/C will include a "Smart Grid Network" (SGN) with innovative algorithms for automatic inversion and resonant cellular approach. The smart grid network will basically 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 controller which 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.

The smart-grid cells will be on-fly arranged in order to substitute the normal monolithic converters, thus reacting to failure events of the converters (or of the voltage busses), and hence allowing for a dynamic grouping of the single cells into logically equivalent complete converters. Power allocation to the different active cells will be defined by the SGN controller, consequently to the evaluation of different variables and parameters.

b) Energy Storage & Regeneration System

The innovative EPDS for Regional A/C will also include an advanced Energy Storage and Regeneration System (ESRS) for the scopes of E2-EM functionalities to be then integrated and tested on the primary electrical network of the Regional Iron Bird. The ESRS will be composed of the following components:

- A Secondary Electrical Power Distribution Centre (SEPDC), embedding a 270 VDC bus bar, with relevant contactors and protections, as well as the controller of the system;
- An Energy Storage Device (ESD) based on supercapacitors, used as a rapid energy buffer;

- A bidirectional DC/DC converter connected to the ESD (both constituting the Energy Storage System, ESS), able to manage the power flows related to the ESD;
- A motor load simulating an Electro-Mechanical Actuator used for primary A/C surfaces or landing gear, as example of regenerative load, without dissipation resistors.

In particular, the ESRS controller will be able to control the behavior of the DC/DC converter, by selecting in each operating phase the conversion direction (buck or boost) and the operation set point, in order to minimize the genator fatigue consequent to a sudden load variation on the HVDC and/or to a regeneration effect as consequence of EMA operation. The selection will be performed by analyzing a set of parameters able to give an indication about the intensity of the power flow managed by the DC/DC converter. Such parameters can include also simulated environmental factors, flight phases and priorities of the loads connected to the SEPDC.

2. Scope of work

Given the above scenario, the objective of this topic is to design, develop, manufacture, test and integrate (at Iron Bird on-ground facilities) an higher level "Centralized Smart Supervisory" (CSS) hardware controller able to manage the lower level controllers of the "Smart-Grid System" and the "Advanced Energy Storage and Regeneration System" (to be provided by other already launched Projects) in order to implement an optimal sharing of the available electrical power on-board during failures and/or overload conditions, thus not relying on main generators overload capabilities.

The Centralized Smart Supervisory control system shall be fully interfaced with the Iron Bird test rig, by activating or deactivating the energy management modes of the SGN and ESRS controllers in case of needs depending on the specific test configuration (reproducing specific aircraft flight phases and/or operating conditions).

The Centralized Smart Supervisory control system shall be able to communicate with other subsystems controllers, as well as with the Iron Bird central control system, by means of appropriate protocols (i.e. CAN). Its main scope will be to coordinate the activities of the local controllers, in order to perform an energy management of the complete system. Different activities are required in order to provide a CSS controller suitable for integration on the Iron Bird and capable of operating successfully with the pre-existant SGN and ESRS controllers.

Analysis

The Topic Manager will provide specification of the SGN and ESRS controllers in a structured manner. The applicant shall analyze the data and incorporate the SGN and ESRS logics into an higher level global logic, for obtaining an optimal power allocation even in case of critical conditions (i.e. failures and overloads).

Design

A formal approach for the CSS controller design, based on mathematical tools, is required in order to provide a successful integration with the local SGN and ESRS controllers. Mathematical frameworks adoption for precise specification of the CSS controller is an asset. Formal proof of correctness are required for the CSS controller design.

Modelling and simulation

Computer based simulation shall be adopted in order to verify the behavior of the CSS controller, by using a detailed modeling in conjunction with the models coming from the SGN and ESRS projects. In particular, the global E2-EM control and monitoring stategy shall be modeled (at functional level) and tested in a simulation environment, by reproducing a representative electrical architecture with relevant equipment, given as an input by the Topic Manager.

The CSS controller model shall permit automatic or semi-automatic translation into a firmware (microprocessor or FPGA or DSP), in order to minimize the chance of programming error. The selected firmware platform shall be suitable for future easy qualification and integration at A/C level.

Manufacturing

The CSS controller core embedding the supervision logics shall be provided as part of an hardware equipment, suitable for its integration on the Iron Bird and capable of communicating with the SGN and ESRS controllers, via CAN network (preferred one but not limited to). Due to its central and critical role, it is required to provide innovative solutions in order to increase the robustness of CAN communication against failures.

Testing

For the purpose of testing activities, techiques such as Hardware In the Loop are required in order to provide evidence of the CSS controller correct operations before its integration on the Iron Bird. After its integration, a specific test campaign shall be performed in order to verify the CSS controller operations against success criteria defined by the Topic Manager, and the expected results coming from the simulation stage.

All the documentation required for allowing the correct electrical, mechanical and control interfaces with the electrical test rig, as well as with the SGN and ESRS subsystems, will be provided to the selected Candidate as an input at the early stage of the Project.

The Supervisory controller and any other equipment referred to in this CfP will be located in a laboratory room for validation and functional tests. Therefore, the environmental requirements shall be limited to a compatibility of the equipment with the laboratory environmental conditions. However, any other qualification activities which can facilitate the preparation of the equipment for next higher level TRL step will be an asset. A detailed Interface Control Document (ICD) will be provided to the selected Candidate detailing all the environmental conditions that the module shall comply with.

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. 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.

FMEA or FMECA analyses shall be provided for failure analyses.

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

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

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

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
Task 1	Requirements analysis: To review the customer requirements, and describe the equipment to be designed, manufactured, validated and provided to the customer for testing.	[T0 ; T0+ 3M]
Task 2	System behaviour and energy management strategy definition: To analyse, design and theoretically proof the effectiveness of the energy management strategy. Software and mathematic tools are required to be used in order to prove the benefits and the formal properties of the designed system and energy management strategy.	[T0 + 3M ; T0+ 9M]

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 3	Preliminary Design: 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]
Task 5	Firmware definition and testing: To define the energy management strategy as a firmware for the computational core of the supervisor. Simulation based approaches shall be used for proving the firmware correctness in terms of energy management objectives achievement.	[T0 + 16M ; T0+ 21M]
Task 6	Critical Design: To realize the detailed design (mechanical, electrical, thermal, …), realize detailed cad drawings, finalize safety analysis, prior to launch equipment manufacturing.	[T0 + 12M ; T0+ 24M]
Task 7	Manufacturing: To manufacture the Supervisory equipment, following the CDR documentation.	[T0 + 24M ; T0+ 30M]
Task 8	Testing and validation: To perform the final tests for validating the Energy management objectives achievement.	[T0 + 30M ; T0+ 34M]
Task 9	Optimization and support: To analyse the feedbacks coming from the customer and provide further support for optimization activities.	[T0 + 34M ; T0+ 36M]

3. Major Deliverables / Milestones and schedule

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	Analysis phase: Requirements matrix and support documentation	R	T0 + 3M
D2	E2-EM definition: Definition of energy management control strategy. Analysis of the results of the simulation models	R/D	T0 + 9M
D3	PDR: Preliminary Design Review and associated deliverables	R	T0 + 12M
D4	Firmware specification: Implementation of a preliminary firmware for energy management purposes	R	T0 + 21M
D5	CDR: Critical Design Review and associated deliverables	R	T0 + 24M
D6	Installation and commissioning: Delivery of the complete system with its associated documentation (preliminary DDP), installation and commissioning on site	R/HW	T0 + 30M
D7	Validation final tests and DDP: Validation test report and final results (final DDP)	R/D	T0 + 34M
D8	Optimization and support: The CfP Supplier shall support the rig operations to correct potential faults during this probation period	R	T0 + 36M

*Types: R=Report, D=Data, HW=Hardware

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	Preliminary Design Review	R	T0 + 12M
M2	Critical Design Review	R	T0 + 24M
M3	Final results	R	T0 + 36M

*Types: R=Report, D=Data, HW=Hardware

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

The Candidate organization shall have:

- expertise in electrical system design (power generation, power conversion, power distribution network, power consumer),
- 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.

5. Abbreviations

A-EPGDS	Advanced Electrical Power Generation & Distribution System
CAN	Controller Area Network
CS2	Clean Sky 2
CP	Core Partner
CSS	Centralized Smart Supervisory
DDP	Declaration of Design & Performance
DSP	Digital Signal Processor
E2-EM	Enhanced Electrical Energy Management
EMA	Electro-Mechanical Actuator
EPDS	Electrical Power Distribution System
ESD	Energy Storage Device
ESRS	Energy Storage & Regenaration System
ESS	Energy Storage System
FMEA	Failure Mode and Effect Analysis
FMECA	Failure Mode, Effects, and Criticality Analysis
FPGA	Field Programmable Gate Array
ICD	Interface Control Document
REG IADP	Regional Integrated Aircraft Demonstration Platform
SEPDC	Secondary Electrical Power Distribution Centre
SGN	Smart Grid Network
SSPC	Solid State Power Controller
TRL	Technology Readiness Level

3. Clean Sky 2 – Fast Rotorcraft IADP

I. Low-speed Air Data Sensor for Tilt-rotor Control

Type of action (RIA or IA)	IA		
Programme Area	FRC		
Joint Technical Programme (JTP) Ref.	NextGenCTR Demonstrator Tiltrotor WP 1.1		
Indicative Funding Topic Value (in k€)	750		
Topic Leader	Leonardo Helicopters	Type of Agreement	Implementation Agreement
Duration of the action (in Months)	72	Indicative Start Date[24]	Q1 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CFP06-FRC-01-13	Low-speed Air Data Sensor for Tilt-rotor Control
Short description	
Improvements in tiltrotor control and performance in the low speed (0-50 knots) regime requires the availability of high fidelity air data. Pneumatic-based air data systems cannot provide this, whereas state of the art laser or microwave systems could. The present activity involves the integration of a proven (min TRL-7) low speed air data system with the flight control system to provide the innovative tiltrotor control in the low-speed regime.	

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

1. Background

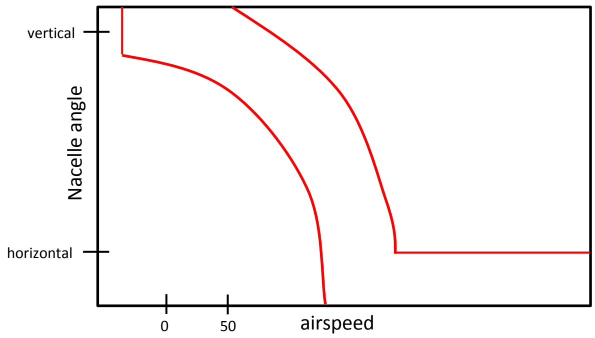
The aim of the Fast Rotorcraft (FRC) project is to use technologies developed through the Clean Sky Programme to demonstrate a compound rotorcraft configuration that combines the vertical lift capability of the conventional helicopter with the speed capability of a fixed wing aircraft in a sustainable way. In the framework of Clean Sky 2 FRC IADP, the present Call requires Partner(s) (company or consortium) to provide innovative engineering solutions for the Tiltrotor NextGen CTR demonstrator air data system in order to improve the control and performance in the low-speed regime. The present document describes also the general requirements that JU shall consider for the selection of the appropriate Partner(s) for this technology development.

Air data systems installed on the majority of aircraft today including current generation tiltrotors are inaccurate once the longitudinal airspeed drops below 40 knots. Consequently, this places limitations on the operation of the aircraft within this envelope, such as:

- Inadvertent excursions into low speed flight regimes with high decent rates may result in aerodynamic disturbances to the proprotors potentially leading to markedly increased decent rate, un-commanded roll, and/or improper responses to pilot inputs;

- Conversion from helicopter to airplane mode requires the aircraft to stay within a safe corridor defined by airspeed vs nacelle angle.

Conversion Corridor



  Therefore the conversion can only be commenced once the airspeed is above 40-50 knots, which may not be the optimal profile through the safe corridor.

- Automatic nacelle angle as a function of airspeed has to be disengaged below 40 knots and managed by the pilots;

- Controllability in quartering flight conditions is particularly weak.

A high-fidelity low speed air data system would provide the means to remove the limitations, provide optimal performance for the flight profile, avoid inadvertent entry into unsafe flight conditions, and improve controllability.

2. Scope of work

The main objective is for the application of a state-of-the-art low-speed air data system (L-ADS) in a novel way to provide a step change in the performance of the tiltrotor. The focus of the innovation is in the application of a low-speed air data sensor to tiltrotor control, rather than the sensor itself. For this reason the partner must be able to demonstrate independently of the NGCTR program that the L-ADS is a flight validated system by CDR (T0+22).

The L-ADS shall capable of providing air data to a specified accuracy, integrity and continuity in all weather conditions, within the aircraft operating environment defined by the following table:

ENVIRONMENTAL CONDITIONS	
Exposure to harsh environment	
Rain, snow and icing conditions	
Altitude envelope:	from -1000ft up to 30000ft
Operating temperature:	from -55°C up to +55°C (as a minimum)[25]
Humidity:	Up 85% humidity conditions as per DO-160G

The system shall provide (as a minimum) the following air data parameters in all flight conditions, from hover at 0 knots to forward flight at 300+ knots:

Parameter	**Range/units**	**Accuracy**
True Air Speed	0 .. 400 knots	± 1 knot
TAS relative direction at speeds < 50 knots	-180 .. 180° with respect to longitudinal aircraft axis	± 1°
Angle of Sideslip	-90 .. 90 degrees	± 0.5°
Angle of Attack	-90 .. 90 degrees	± 0.5°
Pressure Altitude	As per SAE AS8002A	
Altitude Rate (Vertical Speed)	As per SAE AS8002A, with an accuracy of at least 100 ft/min for the low-speed domain (< 50knots).	

The L-ADS shall be able to measure the air data parameters in an air volume unaffected by the air vehicle aerodynamics, (e.g. proprotor inflow). Therefore, no special airflow analysis at the sensor/probe location for calibration purposes shall be necessary as for a conventional air data system.

The L-ADS shall use the minimum number of sensors/probes in order to meet the requirements, but a dual redundant system will be the most likely configuration. The sensors/probes shall be of a minimal size and weight in order to locate them in the most optimal position on the aircraft. The target weight for a single

[25] The system shall be designed to meet operating temperature requirements stated in the table. However, for the NGCTR integration purposes, scope of the present Call for Proposals, operating temperature requirements can be reduced to the envelope from -40°C up to +50°C.

sensor/probe should be 4 Kg or less, and any associated electronic processing unit shall also weigh 4 Kg or less.

Task 1: System Concept

Define the system requirements to specify the installed performance of the L-ADS system based upon the available equipment specification for the L-ADS sensor. The system requirements will be developed jointly with the TM and will specify, amongst others, the safety objectives for the L-ADS.
Develop a system requirements specification (D.1).
Hold an SRR (M1) with the TM to (1) approve the system requirements and (2) review the L-ADS equipment specifications (D.2).

Task 2: System Design

Define the system design to meet the system requirements.
Hold regular reviews with the TM to evaluate the feasibility of the design with respect to the NGCTR platform.
Develop a system design description (D.3).
Hold a PDR with the TM to (1) approve the system design description and (2) review the L-ADS interface control documents (D.4).

Task 3: Installation Design

Work with the TM to define the installation design for the system to cover:

- Space reservations;
- Mechanical and structural interfaces;
- Electrical and wiring interfaces;
- Functional interfaces with the avionic systems.

Develop an installation design description (D.5).
Hold a CDR with the TM to (1) approve the installation design and (2) review/accept the equipment qualification evidence. At this point in the program the partner shall present the Equipment Qualification Evidence (D.6) to demonstrate that the sensor has reached at least TRL 7 and accumulated sufficient flight test hours to successfully validate its performance.

Task 4: Simulation Model Development

The TM uses a pilot-in-the-loop simulator to develop and validate the control laws. This task will provide a software model (D.7) of the L-ADS behaviour which can be integrated into the pilot-in-the-loop simulator to enable the TM to evaluate the control laws that use the L-ADS. The form of the model will be agreed with the TM.

The TM also has a full-scale integration rig (“iron-bird”) for the avionics and flight control system which use real sensors and/or emulations of the sensors for testing the full avionics system. This task will provide an emulation model (D.8) of the L-ADS sensor for integration into the full-scale integration rig.

Task 5: Support to Control Law Development

The TM will use the simulation model (D.7) of the L-ADS integrated into the pilot-in-the-loop simulator to develop and validate the tiltrotor control laws. This task is to provide on-call support to the TM during the control law development.

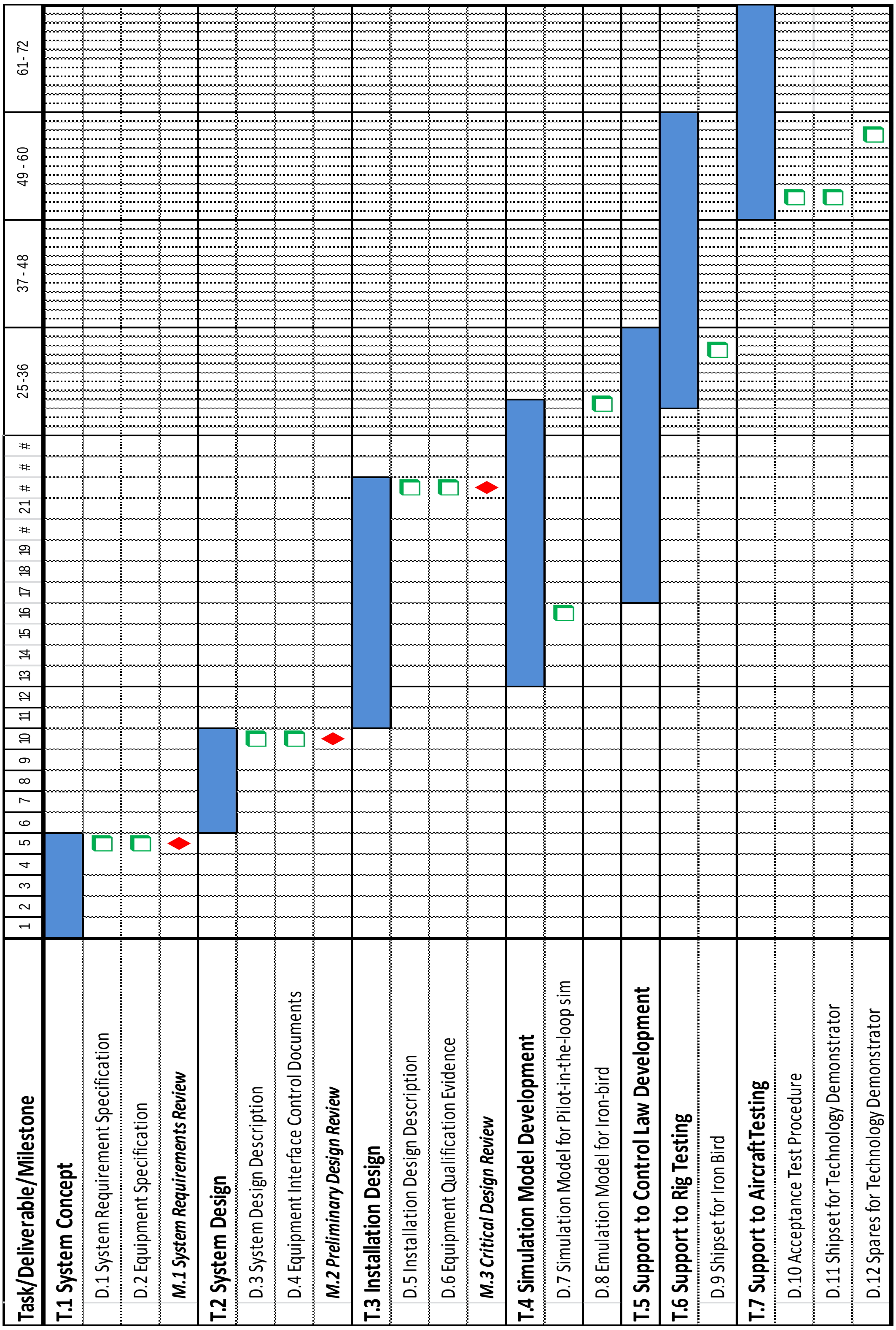
Task 6: Support to Rig Testing

Together with the TM define the L-ADS configuration to be installed on the Flight Control System rig. This shall take into consideration the static nature of the rig, and should be a combination of the emulation model (D.8) and real L-ADS hardware interfacing to the other avionic systems.
Deliver one shipset (D.9) for installation on the Flight Control System rig at the TM premises.

Task 7: Support to Aircraft Testing

In support of the aircraft assembly and test, the partner shall develop an Acceptance test procedure (D.10) to verify: (1) the correct installation of the L-ADS on the aircraft during aircraft assembly, and (2) that the L-ADS meets its installed performance requirements on ground and in flight.
Delivery one shipset (D.11) and spares (D.12) for the aircraft.
Provide support to the TM for ATP execution on the build-line and during ground/flight operations.
Provide on-call support to the TM during flight operations.

The following chart shows the indicative schedule for the project.



The following table will list the deadline for each task completion

Tasks		
Ref. No.	***Title - Description***	***Due Date***
1	System Concept	T0 + 5
2	System Design	T0 + 10
3	Installation Design	T0 + 22
4	Simulation Model Development	T0 + 28
5	Support to Control Law Development	T0 + 36
6	Support to Rig Testing	T0 + 60
7	Support to Aircraft Testing	T0 + 72

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date*** [T0+mm]
D.1	System Requirements Specification	R	T0 + 5
D.2	Equipment Specifications	R	T0 + 5
D.3	System Design Description	R	T0 + 10
D.4	Equipment Interface Control Documents	R	T0 + 10
D.5	Installation Design Description	R	T0 + 22
D.6	Equipment Qualification Evidence	R	T0 + 22
D.7	L-ADS Simulation Model for Pilot-in-the-loop simulator	D	T0 + 16
D.8	L-ADS Emulation Model for Iron-bird.	D	T0 + 28
D.9	Shipset for Iron bird	D	T0 + 34
D.10	Acceptance Test Procedure.	R	T0 + 51
D.11	Shipset for Technology Demonstrator	D	T0 + 51
D.12	Spares for Technology Demonstrator	D	T0 + 58

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	System Requirements Review	RM	T0 + 5
M2	Preliminary Design Review	RM	T0 + 10
M3	Critical Design Review	RM	T0 + 22

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

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

The Applicant shall have proven capabilities and skills in each of the specific areas of this Call, in particular:

- Aeronautic rules, certification processes and quality requirements.
- Design, validation, manufacturing and environmental/functional qualification of avionic 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.
- 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-D0-160, EUROCAE ED-107/ARP-5583, ED-81/ARP-5413 and ED-84/ARP-5412 or equivalent civil or military standards.
- 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.).
- Safety assessment process according to SAE-ARP-4754 and SAE-ARP-4761 standards, willingness to interact closely with TM safety specialists in order to produce the necessary outputs (safety and reliability reports and fault trees/analyses).

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

5. Glossary

CDR	Critical Design Review
CTR	Civil Tilt Rotor
CS2	Clean Sky 2
DC	Direct Current
DDP	Declaration of Design and Performance
EFA	Experimental Flight Approval
EMC	Electro-Magnetic Compatibility
EMI	Electro-Magnetic Interference
FRC	Fast RotorCraft
IADP	Innovative Aircraft Demonstrator Platform
L-ADS	Low-speed Air Data System
NDA	Non Disclosure Agreement
NGCTR	Next Generation Civil TiltRotor
PDR	Preliminary Design Review
SRR	System Requirement Review
TBC	To Be Confirmed
TBD	To Be Defined
TM	Topic Manager
TRL	Technology Readiness Level

II. Contactless measurement system for real time monitoring of proprotor flapping angle

Type of action (RIA or IA)	IA		
Programme Area (ref. to SPD)	FRC		
Joint Technical Programme (JTP) Ref.	NextGenCTR Demonstrator Tiltrotor WP 1.2		
Indicative Funding Topic Value (in k€)	1000		
Topic Leader	Leonardo Helicopters	**Type of Agreement**	Implementation Agreement
Duration of the action (in months)	72	**Indicative Start Date**[26]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CFP06-FRC-01-14	**Contactless measurement system for real time monitoring of proprotor flapping angle**
Short description	
Improvements in tiltrotor performance can be reached with a reliable real-time monitoring of proprotor flapping angle. To overcome reliability and durability limitations due to the challenging operating environment, especially in terms of vibrations, the present topic relates to the provision of a contactless measurement system to be integrated in the proprotor assembly. It shall preferably be based on laser or vision sensor(s), and capable of communicating with the NGCTR avionic system and Flight Test Instrumentation providing actual flap motion. This includes also support to flight test activity.	

[26] 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 a conventional helicopter with the speed capability of a fixed wing aircraft in a sustainable way. In the framework of Clean Sky 2 FRC IADP, the present Call requires Partner(s) (company or consortium) to provide innovative engineering solutions for a proprotor flap angle monitoring system of the Tiltrotor NextGen CTR demonstrator. The present document describes also the general requirements that JU shall consider for the selection of the appropriate Partner(s) for this technology development.

The proprotor of a tiltrotor aircraft (called, more simply, '*rotor*' from now on) is a complex mechanical system operating in a wide and challenging range of conditions, varying, for example, from hovering and low speed maneuvered flight in helicopter mode, to high speed cruise and maneuvering conditions in airplane mode. Thus, the real-time monitoring of some rotor-related quantities, in particular the flapping angle, allows enhancing the performance of tiltrotor operations. Furthermore, an accurate monitoring of the rotor sate could also allow expanding the envelope of possible flight conditions.
The core of the monitoring system is the sensor: conventional and proven sensor technologies, such as Rotary Variable Differential Transformers (RVDTs) or Potentiometers, require complex and potentially delicate mechanical linkages (i.e. levers, bearings, etc.), to be installed in a challenging operating environment, especially in terms of vibrations. On the contrary, innovative contactless sensors, such as those based on laser or vision technologies, could be mechanically isolated from the proprotor hub vibrations, resulting in a potentially more robust and durable installation.

2. Scope of work

The main objective of this CfP is to design, develop and manufacture a new compact, low weight, accurate, reliable and power efficient system capable of real-time monitoring of the proprotor hub flapping angle, within the entire flight and environmental envelopes of the NextGenCTR tiltrotor demonstrator.

The present activity is aimed at integrating the sensor system into the NextGenCTR demonstrator and testing it in flight.

The sensor system does not need to be a flight qualified equipment at program start, but the Partner shall be able to provide all the required documentation to support an Experimental Flight Approval (EFA) release.

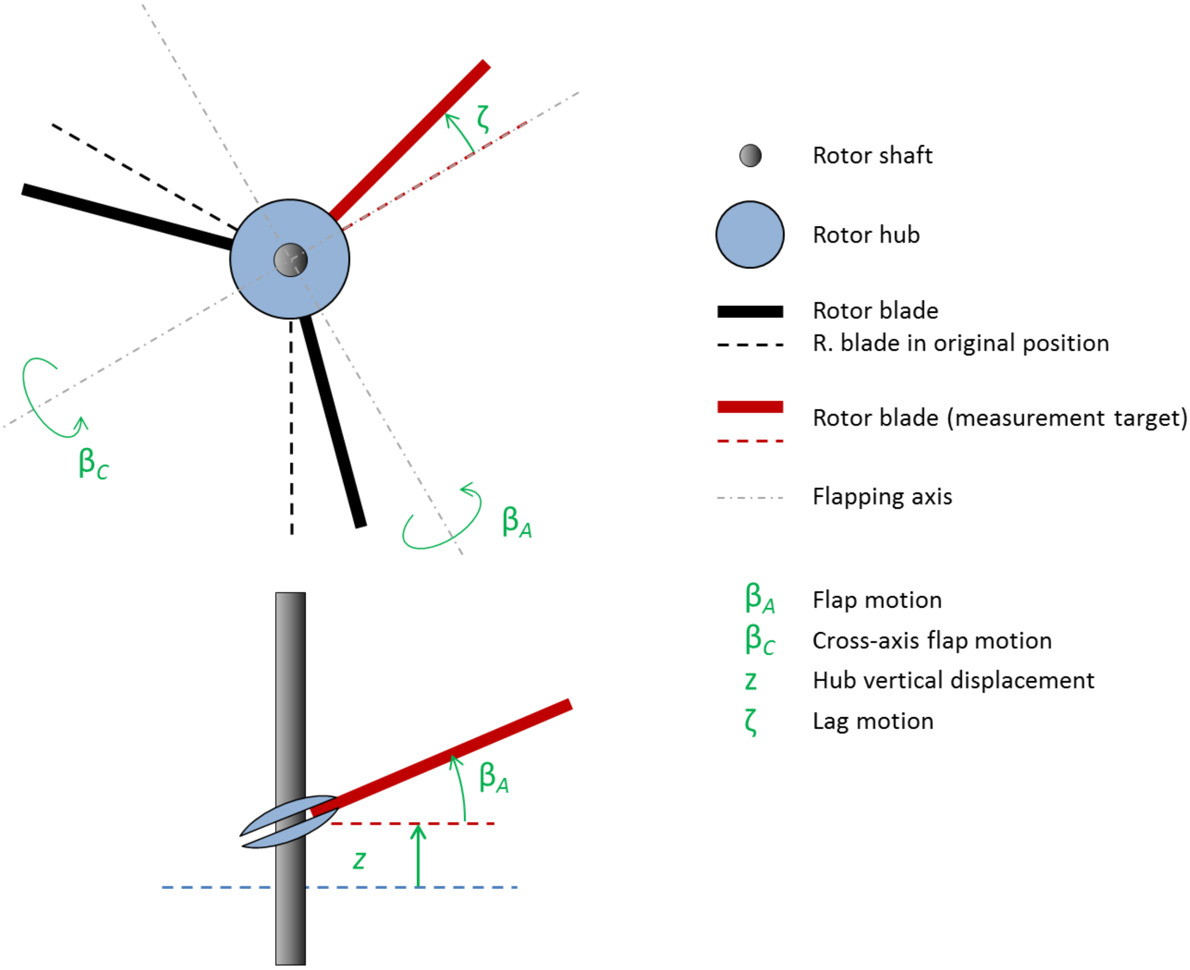
The Partner is also required to support the Tiltrotor manufacturer during the ground and flight test campaign.

a) Quantities to be measured

The system shall provide the value of the following quantities:

ROTOR HUB ANGLE/DISPLACEMENT	Mandatory / Nice-to-have
Rotor Hub Flapping (β_A)	Mandatory
Rotor Hub Cross-Axis Flapping (β_C)	Mandatory
Rotor Hub Lag (ζ)	Nice-to-Have
Rotor Hub Axial Displacement (z)	Nice-to-Have

The figures below show a schematic description of the quantities to be measured by the sensor system; the blade where the sensor is installed is indicated in red.
In case of redundant sensor installation, each one shall target at a different blade.



Some Degrees of Freedom (DoFs) of rotor hub are kinematically coupled, due to the rotor geometry and/or to the limitations in the measurement target localization. The values of any measured quantity shall not be affected by the kinematic coupling with any other measured or non-measured quantity (e.g. β_A and β_C, or β_A and z).

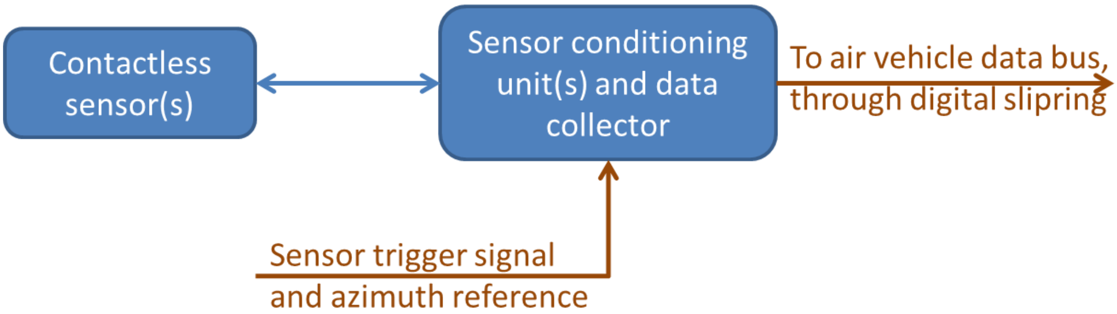
b) System description and requirements

On the final NGCTR-TD, the system shall be installed in each of the proprotor systems (left-wing and right-wing) and include (as a minimum) the following features (see figure below):

- Double redundant contactless sensors, capable of sensing the rotor hub flap angle; if the sensor and/or sensor installation reliability is not high enough, a triple redundant installation shall be preferred;
- A sensor conditioning unit, aimed at
  - Receiving a trigger digital signal from the air vehicle avionic system;
  - Receiving an azimuth reference from the air vehicle avionic system;

- Driving the sensors acquisition simultaneously with the trigger signal;
- Receive the measurement data from the sensors;
- Provide the air vehicle data bus with the rotor hub measured data (one data packet per each sensor), through the slipring.

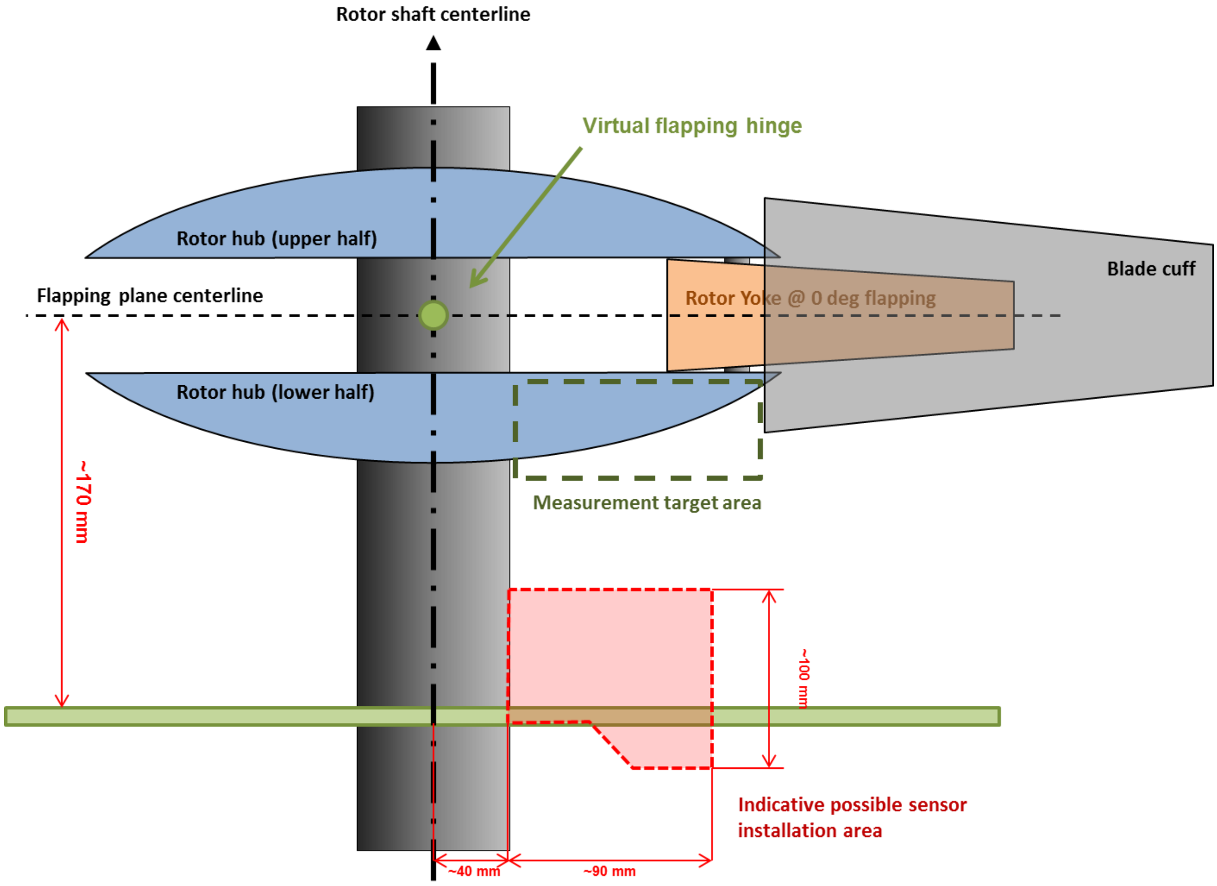
The sensor system shall be designed to have all the I/O interfaces with the tiltrotor avionic system compatible with a digital databus. The details of the interfaces in terms of signal type, protocol, etc. will be provided by the TM in the early stage of the project execution phase.

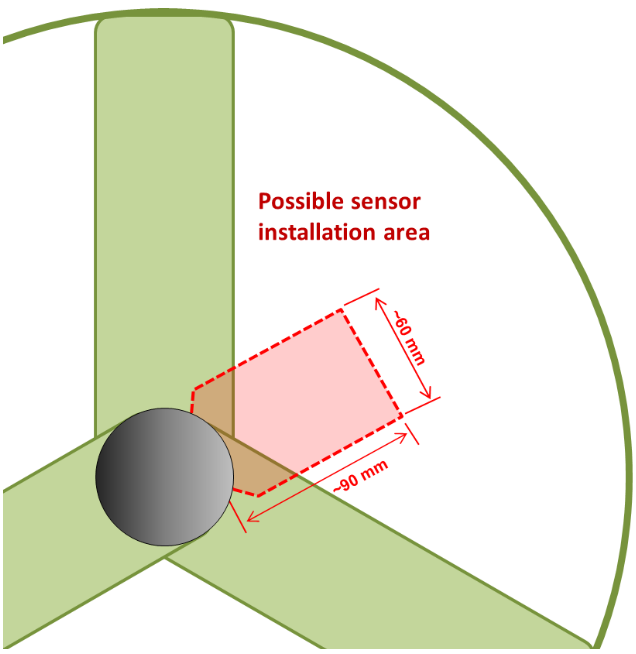


The sensor system configuration, schematically represented in the above figure, shall be defined also in terms of redundancy of sub-systems, components and interfaces to meet the failure probability requirements of a hazardous event.

The applicant shall propose sensor system solutions based on technologies with a maturity of TRL4 at the beginning of the project, as a minimum.

Each sensor shall be installed in the proprotor hub, i.e. in the rotating frame, in an area rigidly connected to the mast (i.e. the rotor shaft). The measurement target shall be the rotor hub, or any part integral with it. A schematic of geometry and an indicative space reservation are represented in the figures below.





The space reservation information should be considered indicative: the detailed space envelope and any deviation from the information provided will be discussed and agreed with the Partner in the project execution phase.

Since the sensor system will be installed in the rotating frame the Partner shall consider the centrifugal force effect when defining the structural requirements.

The sensor system, including sensors, data conditioning unit(s) and all the other features required for its operation, shall comply with the following requirements:

Characteristic	Requirement
Voltage supply	28 VDC
Power requirement	< 100 W per rotor
Accuracy Objective	0.5 deg (mandatory), 0.1 deg (desired)
Weight Objective	< 0.5 kg per rotor
Samples per rotor revolution	>= 24 per rotor

The Partner shall provide the Tiltrotor manufacturer with:

- 1 shipset for test rig integration;
- 1 shipset for NGCTR-TD installation and ground & flight testing, i.e. one sensor system for the left-wing rotor and one for the right-wing rotor. Spare parts shall also be included.

The content of the shipset for rig integration will be defined and agreed with the TM during the project execution phase (Task No. 4).

c) Sensor operating envelope

ENVIRONMENTAL CONDITIONS	
Exposure to harsh environment, including temperature, thermal shock, humidity and vibrations (Ref. DO-160).	
Rain conditions	
Altitude envelope:	from -1000ft up to 30000ft
Operating temperature:	from -55°C up to +55°C (or ISA+40°C for higher altitude)[27]
Humidity:	Up to 100%

ROTOR OPERATING CONDITIONS	
Rotor nominal speed (100%)	569 RPM
Rotor speed range	340 RPM – 680 RPM
Flapping measurement range	±15 deg
Rotor hub axial displacement	0 – 2.5 mm

[27] The system shall be designed to meet operating temperature requirements stated in the table. However, for the NGCTR integration purposes, scope of the present Call for Proposals, operating temperature requirements can be reduced to the envelope from -40°C up to +50°C.

Task 1: System Concept

- Support the TM in the definition of detailed system requirements, in order to meet the performance targets set by the TM.
- Identify the suitable hardware available off-the-shelf and engage hardware manufacturers in case of hardware customization is required.
- Perform a technical risk assessment of the solution proposed, and identify a low-risk backup solution if the risk is relevant.
- Hold an SCR with the TM (M.1).
- Develop a System Requirements Specification (D.1), in agreement with the TM and following the requirements defined in collaboration with the TM.
- Hold an SRR (M.2) with the TM to
  - approve the system requirements, and
  - review the sensor system equipment specifications.
- Issue an equipment specification document (D.2).

Task 2: System Design

- Define the system design to meet the system requirements.
- Hold regular reviews with the TM to evaluate the feasibility of the design with respect to the NGCTR platform.
- Following the System Requirements Specification, develop a detailed system design description (D.3).
- Hold a PDR with the TM (M.3).

Task 3: Installation Design

- In close collaboration with the TM, define the installation design for the system to cover:
  - Space reservations
  - Mechanical, structural and optical interfaces
  - Electrical and wiring interfaces
  - Functional interfaces with the avionic systems
- Develop an installation design document (D.5).
- Hold a CDR (M.4) with the TM to
  - approve the installation design, and
  - review/accept the equipment qualification evidence.
- Present the equipment qualification evidence (D.6) to demonstrate that the sensor system, in its final installation, is suitable to get an Experimental Flight Approval (EFA).

Task 4: Support to Rig Testing

- Together with the TM:
  - support the definition of rotor system test rig requirements and configuration, for sensor system integration and testing;
  - define the sensor system configuration to be installed on the rotor system test rig.

This shall take into consideration the static nature of the rig, and should be aimed at testing the functionality of the final installation design on a representative platform.

- Deliver one shipset for installation on the rotor system rig (D.7) at the manufacturer premises, including all the instruments needed to setup, calibrate and run the sensor system in the rig.
- Provide support to the TM during the sensor system installation, calibration and testing.

Task 5: Support to Aircraft Testing

- Provide the Acceptance Test Procedure (ATP) to be used to verify the correct aircraft installation and operation of the sensor system (D.8).
- Delivery of shipset for aircraft testing (D.9).
- Delivery of the installation and calibration procedure document.
- Delivery of any special tools (mechanical, electronic, hardware and/or software) to support installation/calibration and checkout.
- Provide support to the TM during ATP execution.
- Provide the Qualification Test Procedure (QTP) to verify that the sensor system meets its installed performance requirements (D.10).
- Provide support to the TM during QTP execution.

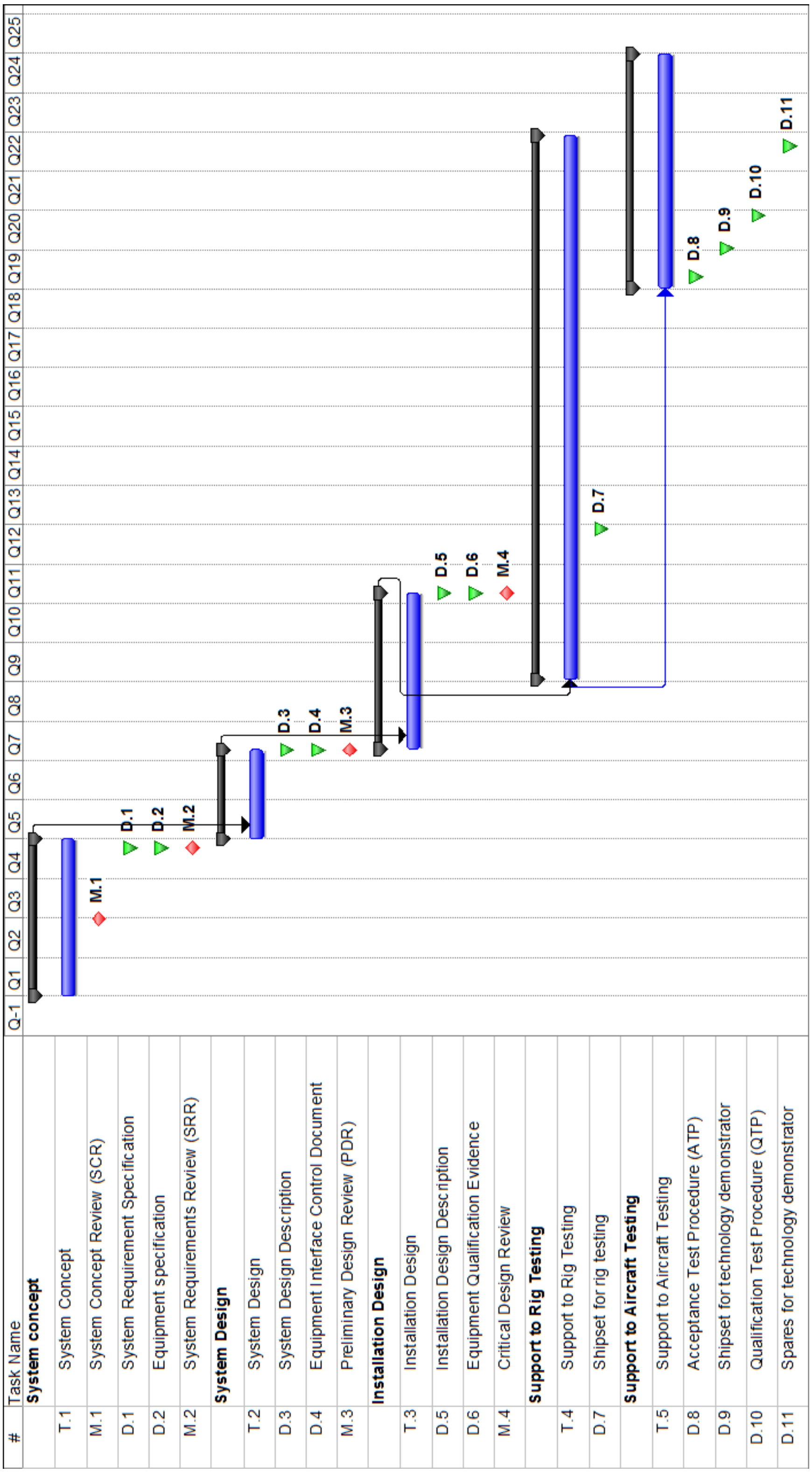
d) General recommendations

Considering the strong impact of a possible project failure on the success of the whole NextGenCTR programme, the Applicant is required to include a task in the first phase of the project dedicated to performing a technical risk assessment of the solution proposed. If the risk is relevant, at the SCR the Partner shall present a low-risk backup solution in addition to the main one.

Particular attention shall be put in including in the proposal a detailed impact assessment of the technology being developed, including a technology exploitation plan and a dissemination plan.

Furthermore, the Applicant is requested to clearly describe in the proposal the work share definition within the working group(s), as well as key skills, work mapping, roles and responsibilities. This is even more important if the Applicant is constituted by a Consortium.

The following chart shows the indicative schedule for the project.



The following table lists the deadline for each task completion

Tasks		
Ref. No.	***Title - Description***	***Due Date***
1	System Concept	T0 + 12
2	System Design	T0 + 19
3	Installation Design	T0 + 31
4	Support to Rig Testing	T0 + 66
5	Support to Aircraft Testing	T0 + 72

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date*** [T0+mm]
D.1	System Requirements Specification	R	T0 + 12
D.2	Equipment Specifications	R	T0 + 12
D.3	System Design Description	R	T0 + 19
D.4	Equipment Interface Control Documents	R	T0 + 19
D.5	Installation Design Description	R	T0 + 31
D.6	Equipment Qualification Evidence	R	T0 + 31
D.7	Shipset for rig testing	D	T0 + 36
D.8	Acceptance Test Procedure	D	T0 + 55
D.9	Shipset for Technology Demonstrator	D	T0 + 58
D.10	Qualification Test Procedure	R	T0 + 58
D.11	Spares for technology demonstrator	D	T0 + 65

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	System Concept Review	RM	T0+6
M2	System Requirements Review	RM	T0 + 12
M3	Preliminary Design Review	RM	T0 + 19
M4	Critical Design Review	RM	T0 + 31

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

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

The Applicant shall have proven capabilities and skills in each of the specific areas of this Call, in particular:

- Aeronautic rules, certification processes and quality requirements. Experience in designing systems compliant with FAR/CS 27/29.
- Design, validation, manufacturing and environmental/functional qualification of systems, according to RTCA-DO-160, RTCA-DO-178 and RTCA-DO-254 (or other civil or military equivalent standards) for safety critical equipments.
- 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-D0-160, EUROCAE ED-107/ARP-5583, ED-81/ARP-5413 and ED-84/ARP-5412 or equivalent civil or military standards.
- 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.).
- Safety assessment process according to SAE-ARP-4754 and SAE-ARP-4761 standards, willingness to interact closely with manufacturer safety specialists in order to produce the necessary outputs (safety and reliability reports and fault trees/analyses).

The Applicant shall also have the availability of one or more experimental lab(s) for structural, fatigue and functional tests on the measurement system.

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

5. Glossary

CDR	Critical Design Review
CTR	Civil Tilt Rotor
CS2	Clean Sky 2
DC	Direct Current
DoF	Degree of Freedom
EFA	Experimental Flight Approval
EMC	Electro-Magnetic Compatibility
EMI	Electro-Magnetic Interference
FRC	Fast RotorCraft
HW	Hardware
IADP	Innovative Aircraft Demonstrator Platform
MTBO	Mean Time Between Overhaul
NDA	Non Disclosure Agreement
NGCTR	Next Generation Civil TiltRotor

NGCTR-TD	Next Generation Civil TiltRotor – Technological Demonstrator
PDR	Preliminary Design Review
RPM	Revolutions Per Minute
SCR	System Concept Review
SRR	System Requirement Review
SW	Software
TBC	To Be Confirmed
TBD	To Be Defined
TM	Topic Manager
TRL	Technology Readiness Level
TRR	Test Readiness Review

III. Interactional aerodynamic assessment of advanced Tilt Rotor configuration

Type of action (RIA or IA)	RIA		
Programme Area	FRC		
Joint Technical Programme (JTP) Ref.	NextGenCTR Demonstrator Tiltrotor WP 1.4		
Indicative Funding Topic Value (in k€)	2200		
Topic Leader	Leonardo Helicopters	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	30	**Indicative Start Date**[28]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CFP06-FRC-01-15	**Interactional aerodynamic assessment of advanced Tilt Rotor configuration**
Short description	
The Topic is aimed to investigate, through a modified existing powered wind tunnel model, the fundamental interactional aerodynamic aspects in the tail region of a tilt rotor. The activity will be accomplished by providing a clear understanding of the efficiency (in terms of aircraft static stability) of different empennage configurations when embedded in the rotor inflows.	

[28] The start date corresponds to actual start date with all legal documents in place.

1. Background

The overall objective of this Call for Proposal is to support, by experimental confirmation, the aerodynamic configuration definition of the novel tilt rotor NGCTR demonstrator. In order to guarantee the correct fulfillment of the design solution dedicated wind tunnel tests are required to support the Empennage definition, with the aim to verify and confirm the key choices of the configurations and to provide guidelines and proposals for potential additional improvement to be implemented.

In order to reduce the expense of the Call and the timeframe to reach results, the exploitation of the outcomes already gathered in previous Research Projects on similar concept/configuration is mandatory. For this reason a strong link with the NICETRIP research program is then required.

The following Key pillars are the main drivers of this Call activity:

- *Interactional Aerodynamics (Rotor inflow into Empennages)*:
    - Basic understanding of the NGCTR layout with two empennage configurations
    - Modification of the existing Nicetrip 1/5th powered model to host the two proposed empennage-like configurations
    - Impact of propeller wakes on the Empennage efficiency and loads of the modified Nicetrip 1/5th model
    - Assessment of the basic NGCTR empennage configurations according to the results of the modified Nicetrip 1/5th model tests
    - Wind Tunnel tests of the tiltrotor model in non-powered configuration; the task is not mandatory, but will constitute a plus for the proposal.

Figure 1 – NICETRIP actual WTT model

2. Scope of work

The Applicant shall structure its Proposal into five main tasks as hereafter described:

- **Task 0**: Management and project coordination
- **Task 1**: Design and manufacturing of the modified powered model (Nicetrip 1/5th) components
- **Task 2**: Wind tunnel tests of the modified full span powered model (Nicetrip 1/5th)
- **Task 3**: Wind tunnel data analysis
- **Task 4**: Empennage assessment of the NGCTR

Task 1: Design and manufacturing of the modified powered model (Nicetrip 1/5th) components

This task includes:

1. Familiarisation with the NGCTR configurations (2 tail geometries) and with the existing Nicetrip 1/5th wind tunnel model
2. Identifications of the main geometrical/configuration changes of the existing Nicetrip 1/5th powered model to be accomplished
3. Empennage models design, based on the NGCTR configurations, to be hosted on the existing Nicetrip 1/5th powered model. The two proposed Empennages, to be compared with the existing T-tail, are a V-tail and a H-tail configurations.
4. Model components manufacturing and instrumentation with suitable interfaces with Wind tunnel acquisition system
5. Model assembly and functionality checks (outside the test section)

Inputs from Topic Leader:

- Existing NICETRIP 1/5th model and supporting documentations will be supplied to the Applicant
- CAD model in CATIA V5 format of the additional 2 tail geometries - T0

Outputs from the Applicant:

- Tiltrotor Powered Model Trade off studies (re-usage and modification of the existing NICETRIP 1/5th model) T0 + 2M
- Tiltrotor Powered Model PDR T0 + 4M
- Tiltrotor Powered Model CDR T0 + 6M
- Tiltrotor Powered Model acceptance T0 + 12M
- Preparation and pre-testing outside tunnel T0 + 14 M

Task 2: Wind tunnel tests of the modified full span powered model (Nicetrip 1/5th)

This task includes:

1. Provision of a large Wind Tunnel able to guarantee the allocation of the model attitudes as needed to support the tail definition and optimization. A wind tunnel with speed capabilities not less than

60 m/sec (in the empty section) meets the requirements. The current existing NICETRIP model has a length of 3,7 m (nose to trailing edge fin), a span of 3,0 m (center nacelle to center nacelle), while the rotors have a diameter of 1,48 m reaching a 2765 RPM in airplane mode.

2. Definition of the test matrix to capture the fundamental flow phenomena on both empennages (The applicant shall assume 10 Wind-on days for cost estimation). The Applicant shall take advantage of previous wind tunnel data, as recorded on the NICETRIP configuration (even at different scale models), in order to build up the most appropriate test matrix to reach the goal. The wind tunnel model will have three main configurations: the NICETRIP Tailoff with T-Tail (The existing NICETRIP model), the NICETRIP Tailoff with V-Tail, the NICETRIP Tailoff with H-Tail. The aim of the tests is to investigate the interactional effects on three different set of Empennages as above (from conversion up to airplane mode), but also rotor-off tests should be added as an option in order to complete the data base of the configurations to capture relevant phenomena on the basic fuselage with different Empennages. As far as the wing, nacelles and rotors the existing NICETRIP model components will be maintained. The Applicant, in cooperation with the ITD leader, will issue the test matrix in order to guarantee the capturing of the relevant phenomena and the aerodynamic data suitable to address and support the choice of the most suitable empennage configuration. The model attitudes, the rotor trim data, the nacelle positioning will be defined during this test matrix preparation. Being the total days of tunnel occupation not predictable at this stage, in the Proposal the Applicant shall justify the relative quotation in harmonisation with the proposed strategy to finalise the configuration (Task 4).
3. Safety Piloting of the model
4. Measurements of model main aerodynamic steady loads using the existing 6 components model balances (1 tail balance and 2 rotor balances). The measurement of the overall model aerodynamic loads shall be also required, by means of an external 6-components balance to be provided by the applicant.
5. Capability to manage the acquisition of steady (672 existing static taps) and unsteady surface pressures (54 existing kulite sensors).

Inputs from Topic Leader:

- Existing NICETRIP models (powered and non-powered) wind tunnel tests and supporting documentations will be supplied to the Applicant as needed

Outputs from the Applicant:

- Test Matrix Report - T0 + 14 M
- Raw data of the tunnel tests - T0 + 16 M

Task 3: Wind tunnel data analysis

This task includes:

1. Delivery of the force and moments data report, in a condensed and readable format to be agreed with ITD
2. Delivery of the surface pressure (static and dynamic) report, in a condensed and readable format to be agreed with ITD

3. Analysis of the static stability behaviour of the model according to the different empennage installations embedded into the rotor flow fields (and in the isolated fuselage configuration as an option), in a condensed and readable format to be agreed with ITD

Inputs from Topic Leader:
- Condensed and readable format and conventions T0 + 12M

Outputs from the Applicant:
- Wind tunnel entry – T0 + 16 M
- Force and moments report – T0 + 18 M
- Analysis of the stability – T0 + 20M
- Surface pressure report – T0 + 20 M

Task 4: Empennage assessment proposals suitable for NGCTR

This task includes:
1. Definition of an optimum strategy approach that, taking advantages of the wind tunnel data gathered in Task 2 (including the acquisition of specific parameters to support it) and from previous Nicetrip models test campaign (even not powered) will drive the assessment of the Empennage configuration on the NGCTR
2. Enhancement of the Empennage NGCTR performance by proposing, in coordination with the ITD, geometry modifications of the NGCTR tail surfaces. This proposed geometry modification (modification with respect to the configuration tested into wind tunnel in Task 2) will be substantiated by CFD analysis only.

Inputs from Topic Leader:
- Main aerodynamics requirements of the NGCTR – T0 + 6 M
- Tail unit structural and geometrical constraints of the NGCTR – T0 + 14 M

Outputs from the Applicant:
- Assessment of the NGCTR empennage configurations – T0 + 30 M
- Improved Tail unit proposals – T0 + 30 M

The following table will list the deadline for each task completion.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
1	Design and manufacturing of the modified powered model (Nicetrip 1/5th) components	T0 + 14
2	Wind tunnel tests of the modified full span powered model (Nicetrip 1/5th)	T0 + 16
3	Wind tunnel data analysis	T0 + 20
4	Empennage optimization proposals suitable for NGCTR	T0 + 30

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date*** [T0+mm]
D.1	Tiltrotor Powered Model Trade off studies	RM	T0 + 2
D.2	Tiltrotor Powered Model acceptance	R/D	T0 + 12
D.3	Test matrix	R	T0 + 14
D.4	Raw data from Wind Tunnel Test	R	T0 + 16
D.5	Force and moments report	R	T0 + 18
D.6	Analysis of the stability report	R	T0 + 20
D.7	Surface pressure report	R	T0 + 20
D.8	Empennage optimization proposal report	R	T0 + 30

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Tiltrotor Powered Model PDR	RM	T0 + 4
M2	Tiltrotor Powered Model CDR	RM	T0 + 6
M3	Tiltrotor Powered Model Test Readiness Review	RM	T0 + 13
M4	Tiltrotor Powered Model Wind Tunnel Entry	RM	T0 + 14

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

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

The Applicant shall have proven capabilities and skills in each of the specific areas of this Call, in particular:

- Powered rotorcraft model design, instrumentation and manufacturing
- Management and conduction of rotorcraft wind tunnel tests on powered models
- Proof capability in managing data acquisiton and post-processing of highly instrumented wind tunnel models
- Proof experience in managing the aerodynamics of Tilt rotor
- Numerical CFD Optimization
- Management of Projects at International level

Due to the wide required capabilities, a Consortium gathering excellences is encouraged to respond.

IV. Lateral rotor noise prediction dedicated to low noise footprint optimisation of a compound helicopter

Type of action (RIA or IA)	RIA		
Programme Area	FRC		
Joint Technical Programme (JTP) Ref.	WP 2.1.2.5 & 2.12.3		
Indicative Funding Topic Value (in k€)	800		
Topic Leader	Airbus Helicopters	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[29]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2016-CFP06-FRC-02-20	**Lateral rotor noise prediction dedicated to low noise footprint optimisation of a compound helicopter**
Short description	
The aim of this topic is to develop a computation tool for prediction of noise of the lateral rotors installed on a compound helicopter. This tool is to be used afterwards to optimise flight path in order to obtain low noise footprint.	

[29] 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 Program, 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 topic relates to the FRC low community noise impact. Following the works in Clean Sky 1 Green RotorCraft (GRC5), many progresses were made in the frame of Low Noise Procedures (LNP) design on classical helicopters. Recall that LNP allow lowering the ground noise level related to H/C mission through the fine management of its position and speed. It is therefore planned to implement this technology on FRC.

Nevertheless, due to the very specific architecture of the FRC, there is a need for modelling the lateral rotor noise on the entire flight domain.

2. Scope of work

The partner shall developp a tool able to modelize the noise of an lateral rotor (i.e. ensuring antitorque and/or propulsion) of various dimensions in multiple operating conditions. The tool shall be able to provide noise levels on a relevant frequency domain in far field as well as in near field, simulated microphone positions being set through user control.

The tool components shall be either partner's property (already existing or developped in the partnership), or commercial tools (i.e. available on the market and provided by a 3rd party). In the latter case, licencing conditions will have to be specifically discussed between partner and topic leader.

The tool shall be made available to the topic leader (Airbus Helicopters and Airbus Helicopters Deutschland) during the whole duration of the CleanSky 2 project as well as 2 years after the final date of CleanSky 2, including related updates and maintenance. Topic leader subcontractors shall also be given unlimited access to the tool. If deemed necessary, the licencing conditions regarding the continuation of the utilization of the tool afterwards by the topic leader shall be specifically discussed between partner and topic leader.

In order to accurately capture the lateral rotor noise, aerodynamic comportment shall also be characterized by the computation chain. The acoustic comportment of the lateral rotor shall be derived from aerodynamic information (e.g. through Ffowcs-Williams Hawkings formulation). Complex propagation effect (fuselage and/or wing scattering) shall be handled in an another component. A proposed flowchart is displayed on figure 5.

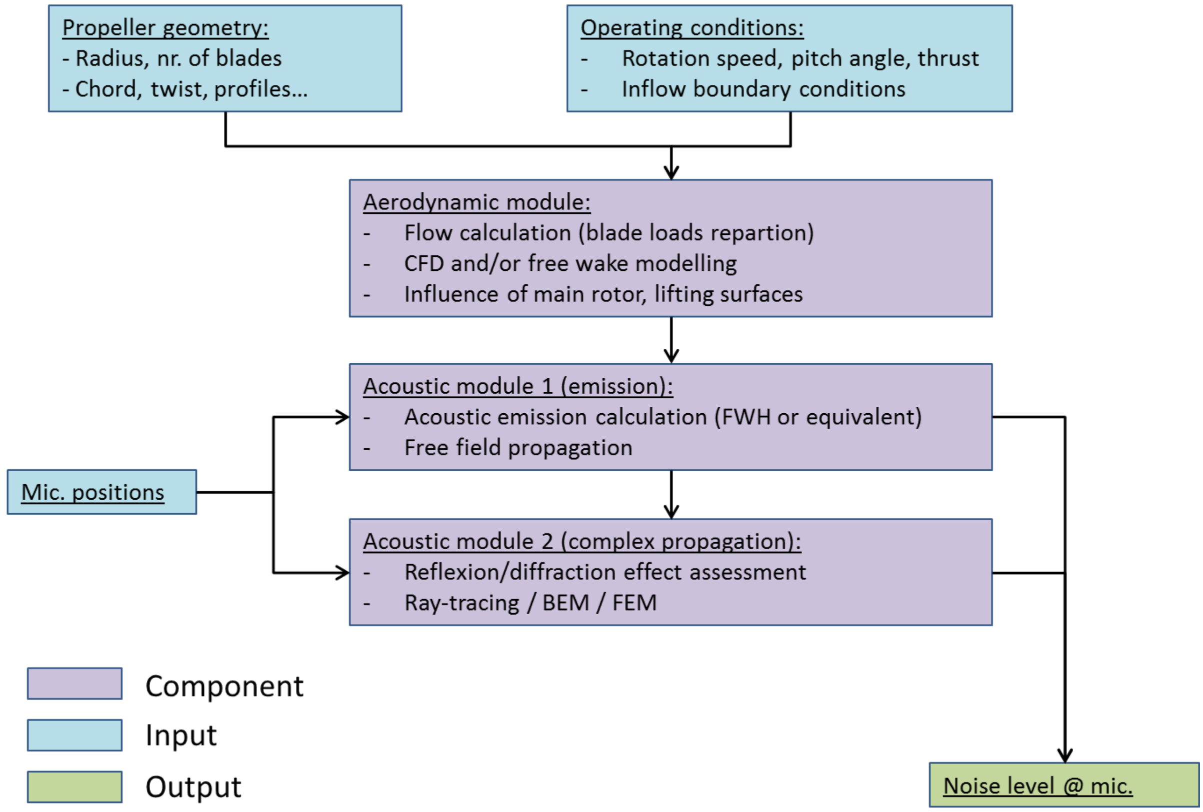


Figure 5: Tool flowchart proposal

As the lateral rotor is aimed at equipping an H/C which holds a much extended flight domain than a fixed-wing A/C, the tool shall capture acuratelly the aerodynamic and aeroacoustic comportment of the rotor either for advancing inflows (flow coming from H/C nose), reverse inflows (flow coming from H/C tail) and lateral inflows applying to both positive and negative thrusts. The tool shall remain representative in configurations with incidence (significant side-slip and/or attack angle). Complex rotor blades (holding non-unifrom sweep, twist, anhedral, chord laws, multiple profiles and advanced tips) influence shall be captured. The tool shall also efficiencly capture the effect of modulation (non-constant blade phasing) on lateral rotor noise level.

The tool shall be able to capture the rotor noise upon the FRC whole flight domain. If the tool is unreliable or inaccurate on a portion of the flight domain, this limitation shall be communicated to the topic leader and the final user of the computation chain. Partner shall evaluate the tool on a subset of the flight domain defined by topic leader prior to delivery.

The flight domain to be covered by the tool corresponds to a compound helicopter (0 to 300 kts) and adresses all possible stabilized configurations of level flight, cimb, descent, hover and lateral flight. Furthermore, the ability of the tool of capturing rotor noise during instationnary flights (maneuvers) is an asset.

Aerodynamic interactions with neighbouring lifting surfaces (being either direct or potential) or additionnal rotating elements (e.g. main rotor downwash) shall also be captured by the tool and related effects in terms of noise shall be quantified. The choice of methodology to capture these effects (wake methods, CFD…) is up to the partner. The capacity of the chosen methodology to efficiently capture these effects shall however be demonstrated. The aerodynamic field shall be expressed either on the blade surfaces or on a so-called porous surface surrounding the rotor. The acoustic emission module shall be capable of deriving the acoustic field using the 2 kinds of surfaces, and of propagating the acoustic wave in free field at various microphone positions. The capability of capturing of quadripolar noise (turbulence self-noise) is an asset but not mandatory.

In its last step, the tool shall capture acoustic installation effect such as reflexion/diffraction upon FRC fuselage and wings (acoustic complex propagation module). Again, the choice of methodology to capture these effects is up to the partner (BEM, ray-tracing…). The related module shall be optional while using the tool. A trade-off shall be done between the accuracy of the results and the tool computation time.

The workflow of the tool shall allow for a clear understanding of the interactions between its different components. Inputs and outputs shall be clearly documented and as far as possible self-understanding. Preffered formats are tecplot, matlab and python compatible. Binaries can be optionnaly used (through user setting), but the tool shall always give the possibility to output its results in text format, which is by default preferred. These recommandations apply also to intermediate results (e.g. aerodynamic results, free field noise levels…) which shall be also accessible to the user.

Warning and error messages shall be clearly stated and documented. Utilization shall be made as transparent as possible. Use of a modern, interpreted language (e.g. python) as interface of the different tool components (aerodynamics, noise and installation effects) is an asset. Compiled languages (fortran, C) can be used for individual components of the tool (aerodynamic and acoustic modules) as these languages classicaly allow faster computation time. The use of recent version of the languages (e.g. fortran 90 and above) is an asset. Dynamic memory allocation is an asset.

The tool shall be running preferably under Unix/Linux environment, yet a Windows© installation can be considered. Parallelisation of the components shall be used as far as possible. Graphical User Interface can be considered and is an asset, yet all functionnalities shall also be available in batch mode in order to allow for coupling with the optimizer.

In order to ensure portability of the tool, the tool binaries will have to be provided compiled on a series of several environments to be discussed with topic leader.

Tasks		
Ref. No.	Title – Description	Due Date
0	**Project Management**	T0 – T0 + 36
1	**Workflow definition & implementation** – Implementation of the tool data workflow.	T0 – T0 + 36
2	**Aerodynamic simulations** – Implementation & validation of the lateral rotor aerodynamic module. Validation on agreed test cases.	T0 - T0 + 8

3	**Acoustic module 1** – Implementation and validation of the rotor acoustic emission module. Validation on agreed test cases.	T0 + 8 - T0 + 20
4	**Acoustic module 2**– Implementation and validation of the rotor acoustic complex propagation module. Validation on agreed test cases.	T0 + 14 - T0 + 26
5	**Test cases** – Application of the tool on a subset of the FRC flight domain.	T0 + 26 - T0 + 36

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type	Due Date
In1	Geometric and aerodynamic description of the rotorcraft	Topic Leader data delivery to Partner	T0
In2	List of flight cases to be computed	Topic Leader data delivery to Partner	T0
D1-1	Document describing the method and detailed tools used	Document	T0 + 3
D1-2	Software package and associated documentation for aerodynamic simulation and test case delivery	Software + document	T0 + 8
In3	Feedback from Topic leader about deliverable D1-2	Document	T0 + 10
D1-3	Optional update of deliverable D1-2 i.a.w. feedback In3	Software + Document	T0 + 12
D2-1	Software package and associated documentation for acoustic module 1	Document	T0 + 20
In4	Feedback from Topic leader about deliverable D2-1	Document	T0 + 22
D2-2	Optional update of deliverable D2-1 i.a.w. feedback In4	Software + Document	T0 + 24
D3-1	Software package and associated documentation for acoustic module 2	Document	T0 + 26
In5	Feedback from Topic leader about deliverable D3-1	Document	T0 + 28
D3-2	Optional update of deliverable D3-1 i.a.w. feedback In5	Software + Document	T0 + 30
D5	Results of application to In1 and In2	Document + results files	T0 + 34

D6	Exhaustive document summarising the achievements, the difficulties encountered and the lessons learned	Document	T0 + 36

Note 1: In1 and In2 may be updated by the topic leader. A schedule of updates will be defined and agreed after partner selection.

Milestones (when appropriate)			
Ref. No.	Title - Description	Type	Due Date
M1	Kick-off meeting	Meeting	T0
M2	Review of inputs	Review + Decision	T0 + 4
M3	Software and tool development intermediate review for aerodynamic module	Review + Decision	T0 + 5
M4	Software and tool development intermediate review for acoustic module 1	Review + Decision	T0 + 14
M5	Software and tool development intermediate review for acoustic module 2	Review + Decision	T0 + 21
M6	Application of tool to test case : review of results	Review	T0 + 34

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

Successful applicants will have a qualified and demonstrable skill set in aerodynamics, aeroacoustics and numerical tools disciplines and a track record in relevant industry sectors. Evidence of publications in the relevant journals or forums would be a good indicator of expertise in the field.

Special Skills

- 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.
- Competence in management of complex softwares (e.g. use of versioning tools).

V. Emergency Exits and Cabin Footstep for the Fast Rotorcraft

Type of action (RIA or IA)	IA		
Programme Area	FRC		
Joint Technical Programme (JTP) Ref.	WP 2.2 Airframe Structure		
Indicative Funding Topic Value (in k€)	700		
Topic Leader	Airbus Helicopters	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	60	**Indicative Start Date**[30]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-FRC-02-21	**Emergency Exits and Cabin Footstep for the Fast Rotorcraft**
Short description	
This project within the Fast Rotorcraft development consists of the design, manufacturing, assembly and documentation of the helicopter sub systems Emergency Exits and Cabin Footstep for Search and Rescue missions. Moreover, the support during final assembly line and flight test phase is also included in this work package. The Emergency Exits must ensure the evacuation of the aircraft according to CS29 and the latest recommendations provided by the airworthiness authorities.	

[30] 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 Program, 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 a high cruise speed, low fuel consumption, low community noise impact and excellent mission capabilities for operators. A large scale flightworthy demonstrator embodying the new European compound rotorcraft architecture will be designed, integrated and flight tested.

One of the key missions of the Fast Rotorcraft will be Search and Rescue (SAR) and Emergency Medical Services (EMS). The Fast Rotorcraft will offer huge benefits for these missions with the combination of high cruising speed and long range.

2. Scope of work

The subject of this Call for Proposals is to cover the full development and manufacturing of the flightworthy Emergency Exits and Cabin Footstep for the FRC demonstrator. All activities must be performed in close cooperation with the Topic Manager (TM).

This call consists of the design and sizing of the previously mentioned parts, starting with existing architecture and concepts provided by TM. The partner will be responsible of the selection of the materials, manufacturing processes and the related quality assurances according to aeronautical standards. Activities of project management, engineering, manufacturing and tests have to be performed by the Partner. In addition, the partner has to provide the documentation, which is requested by the Topic Manager and which is required to achieve Permit to Flight (PtF).

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 0	Start of Innovative Action: Input Delivery by Topic Manager	T0
Task 1	Preliminary Design of Emergency Exits and Cabin Footstep.	T0 + 6 months
Task 2	Detailed Design of Emergency Exits and Cabin Footstep.	T0 + 13 months
Task 3	Manufacturing and testing of mock-up parts	T0 + 18 months
Task 4	Manufacturing and testing of flightworthy parts	T0 + 21 months
Task 5	Provide documentation for Permit to Fly (PtF)	T0 + 23 months
Task 6	Support to Final Assembly Line	Until to T0 + 27 months
Task 7	Support to Flight Testing Phase	Until to T0 + 60 months
Task 8	Completion of Clean Sky 2 activities	T0 + 60 months

General remarks:

- The Emergency Exits shall be designed acc. to the requirements from CS29 and the latest recommendations given by EASA and UK CAA.
- The Emergency Exits shall be designed as an evolution of the latest introduced systems in the helicopter industry.
- This workpackage will require a close collaboration with the TM and other existing partners in order to harmonize interfaces and for the realization of optimized sub-systems.
- The substantiation documentations have to be done according to 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).

Explanation of the sub-systems of this call

a) Emergency Exits:

The Clean Sky 2 partner has to develop and manufacture three flightworthy Emergency Exits:

1. Left Cockpit Emergency Exit with included bad weather window, shown in Figure 6
2. Right Cockpit Emergency Exit, similar to left one, but without bad weather window
3. One Cabin Emergency Exit, shown in Figure 7, type IV acc. to CS29-807

The main functional requirements for these parts are:

- Safe emergency exit capability acc. to the requirements from CS29, Topic Manager and recommendations by airworthiness authorities
- The Emergency Exits shall be designed as jettisonable windows with a composite frame linked to the surrounding structure

- Excellent external visibility, especially for cockpit emergency exits
- Resistance to aerodynamic pressure
- Air and water tightness
- Soundproofing
- Emergency exits shall be operated from the inside and outside of the helicopter one handed
- The emergency exits shall be reusable
- The locking status of the Emergency Exits must be indicated at the inside of the helicopter
- The release mechanism must enable an easy adjustment
- The windows within the Emergency Exits are included in this call
- The sealing of the Emergency Exits to the surrounding structure shall be realised with at least a double barrier sealing

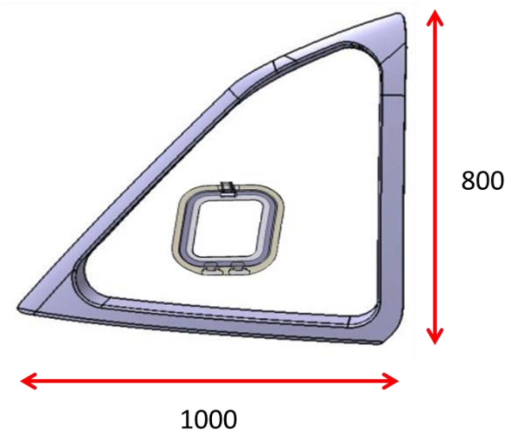


Figure 6: Left Emergency Exit with included bad weather window

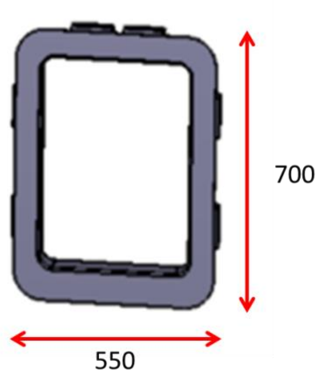


Figure 7: Cabin Emergency Exit

Note: Dimensions are preliminary, final figures will be part of the specification delivered at T0.

b) Cabin Footstep

The Cabin Footstep will be used for SAR missions. The main design and functional requirements are:

- The Cabin Footstep shall be stored inside the external fuselage surface (closed position) when it is not in use with a minimal gap to surrounding structure to reduce aerodynamical drag.
- The current concepts features a kinematic (e.g. rotation), which moves the footstep from the storage position to the operational position outside of the external fuselage surface.
- The operation of the Cabin Footstep shall be possible on ground and during flight. The flight conditions will be defined and provided to the partner.
- The Cabin Footstep shall be compatible with hoisting operation and shall not endanger the hoisting mission, the hoisting equipment and the involved persons.
- The mechanism of the Cabin Footstep should be electrically actuated with an operation from the inside and the outside of the cabin.
- The Cabin Footstep shall be locked in closed and opened position with a direct visualisation of the locking status inside and outside of the cabin and within the cockpit.
- The dimensions of the Cabin Footstep are shown in Figure 8 in the open position.
- This CfP includes the complete perimeter of this subsystem and it's installation within the aircraft. The main parts are:
    - the footstep
    - the hinges and parts linked to the mechanism
    - definition and integration of the actuation means
    - a partition wall (green) to separate the footstep from the interior
    - all the parts necessary for the installation into the aircraft

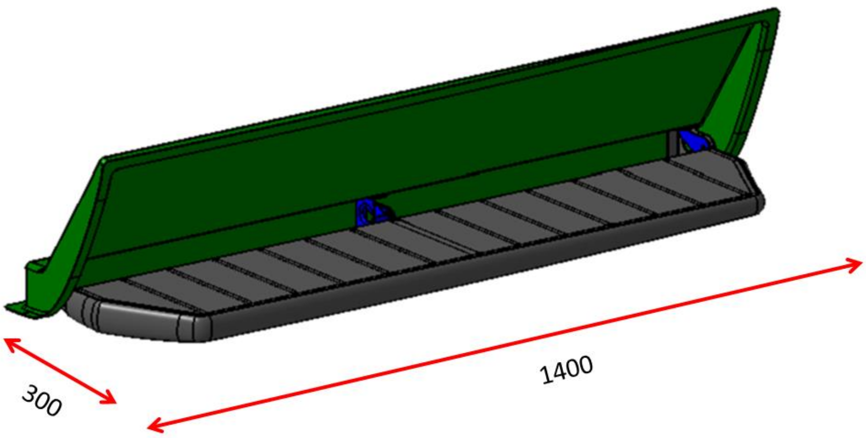


Figure 8: Cabin Footstep

Note: Dimensions are preliminary, final figures will be part of the specification delivered at T0.

Task 0: Inputs Delivery by the Topic Manager

The Topic Manager will provide to the Partner the following information:

- CAD files (CATIA V5 R21) including concepts, space allocations and surrounding structure
- Structural loads and thermal conditions
- Functional/requirement specification.

Task 1: Preliminary design of Emergency Exits and Cabin Footstep

The partner has to realize a preliminary design according to the inputs delivered by the Topic Manager. The preliminary design must have a sufficient maturity to validate the select the concepts for the following detailed design phase.

This task requires peculiar attention of:

- The CAD design (CATIA V5 R21) must contain all parts demonstrating the concepts
- Interfaces to surrounding structures must be frozen
- Performance: Minimum impact on overall drag of the helicopter, flush integration into the surrounding structure
- The Emergency Exits must follow the latest recommendations of the Airworthiness Authorities
- Weight: Light weight design, status regularly reported to TM
- Cost: Low recurring cost (RC)
- Selection of materials and manufacturing processes
- Planning of required test activities
- Risk analysis and mitigation plan

The Topic Manager will provide the templates and required content for the Preliminary Design Review (PDR) to the partner at T0.

Task 2: Detailed Design

Within the Detailed Design Phase, the partner has to realize the detailed design and sizingfor the Emergency Exit and the Cabin Footstep. This phase will confirm the weight and functional targets and will enable the start of manufacturing.

The main tasks are:

- CAD design finalized with 3D and 2D drawings released
- Complete sizing and stress substantiation
- Weight: Light weight design, status regularly reported to TM
- Tooling and manufacturing are planned
- Documentation of compliance

The Topic Manager will provide the templates and required content for the Critical Design Review (CDR) to the partner in time.

Task 3: Manufacturing and testing of mock-up parts

The Partner has to demonstrate the feasibility and reliablity of the developed designs by manufacturing and testing of the mock-up parts. The scope of this task will be defined together by the partner and the Topic Manager.

Task 4: Manufacturing and testing of flightworthy parts

The Partner has to manufacture the Emergency Exits and the Cabin Footstep with a proven mature technology in order to be able to safely reach the required technology readiness for the flightworthy parts. The parts have to be delivered with the all documentation necessary to prove compliance with the design and previously agreed quality standards.

Task 5: Provide documentation for PtF

Manufactured parts must meet airworthiness criteria as defined by the Topic Manager to fulfill Permit to Fly requirements. Flightworthiness and functionality could be demonstrated through dedicated tests and inspections. The Topic Manager will provide the Partner a list of required documents at PDR.

Task 6: Support to Final Assembly Line

The partner must be available for support topics during the final assembly phase of the demonstrator. This support includes adjustments, redesigns, modification, retrofits and spare parts.

Task 7: Support to Flight Testing Phase

The partner must be available for support topics during the fligth testing phase of the demonstrator. This support includes redesigns, modification, retrofits and spare parts.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D 1	Preliminary 3D CAD data of all parts within this work package, detailed weight estimation	Doc	T0+6
D 2	3D CAD data with frozen interface requirements	Doc	T0+6
D 3	Detailed 3D CAD data and manufacturing drawings	Doc	T0+13
D 4	Test report of tests performed on mock-up parts	Doc	T0+18
D 5	Delivery of all flightworthy assembled parts	HW	T0+21
D 6	Final Permit to Fly documentation	Doc	T0+23

Milestones			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M 1	PDR	MS	T0+6

M 2	CDR	MS	T0+13
M 3	Delivery of all flightworthy assembled parts	MS	T0+21
M 4	Project end	MS	T0+60

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

Airworthiness:

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 Permit to Fly related activities. Therefore the Partner has to provide all documentation necessary to achieve "Permit to Fly" and take action allowing this goal to be reached:

- Providing required description documents, analysis, stress substantiations and test reports
- Providing material data and description of manufacturing process 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;
- TRL level 4 must be reached for each system/technology upon project start. 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. At the end of the project, 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

The topic of Life Cycle Analysis (LCA) is dealing with environmental impacts of technologies (energy, VOC, waste, etc.). Within Clean Sky 2, the Partner is required to support the Topic Manager with the required information for the analysis. This Eco-design topic will be integrated during design and manufacturing phases. The Topic Manager will support the LCA approach (Methodologies training or pilot cases).

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 (at least 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 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 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.

All parts are expected to be corrosion protected and all CFRP parts shall be delivered with primer paint. The stepping area of the Cabin Footstep is expected to feature a durable and appropriate anti-skid surface.

Special Skills

<u>Abbreviations</u>: (M) for Mandatory; (A) for Appreciated.

- Proven experience in design and manufacturing of Emergency Exits for aeronautical applications on non-pressurised aircrafts or rotorcraft (M)
- Experience in design of metallic and composite aeronautical structures (M)
- Experience in sizing of metallic and composite aeronautical structures (M)
- Experience with build-to-spec approach for aeronautical applications (M)
- Experience in design of kinematic systems (M)
- Experience in manufacturing and assembly of kinematic systems (M)
- Experience in design, sizing and manufacturing of adhesive bonding of composite, metallic and Window materials (e.g. PMMA) (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 provide 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 perform risk analysis and risk mitigation actions (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)
- Design tools of the aeronautical industry (i.e. CATIA v5 release 21) (M)
- Product Organization Approvals (POA). (M)
- Quality System acc. to international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004) (M)
- Design Organization Approval (DOA). (A)
- Qualification as Material and Ground Testing Laboratory of reference aeronautical companies (i.e. ISO 17025 and Nadcap). (A)
- 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)
- Advanced Non Destructive Inspection (NDI) and components inspection to support new processes in the frame of an experimental Permit to Fly objective. (A)
- Qualification as strategic supplier of structural test on aeronautical elements. (A)

5. Additional information:

The partner and the Topic Manager will have to agree and sign during the negotiation (before T0):

- An Implementation Agreement as defined by Clean Sky2
- A Specific Agreement for the loan of material/equipment for integration tests on ground and in flight to cover aspects linked to the delivery by the partner of flying equipment (obligation of the parties, product liability, insurance aspects for the partner), possibility to extend the loan after the end of Clean Sky 2.

VI. Lateral rotor declutching mechanism for a fast compound rotorcraft

Type of action (RIA or IA)	IA		
Programme Area	FRC		
Joint Technical Programme (JTP) Ref.	WP 2.6		
Indicative Funding Topic Value (in k€)	900		
Topic Leader	Airbus Helicopters	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[31]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2016-CFP06-FRC-02-22	**Lateral rotor declutching mechanism for a fast compound rotorcraft**
Short description	
The LifeRCraft demonstrator is a fast compound rotorcraft. The aim of this CfP is to study, design, manufacture and test a demonstrator of a declutching device that could be integrated in the drive system of the LifeRCraft to allow stopping one lateral rotor without stopping the whole dynamic system.	

[31] The start date corresponds to actual start date with all legal documents in place.

1. Background

The architecture of the LifeRcraft fast compound rotorcraft asks for new functions. One of them brings a key feature to the aircraft : the capacity to stop lateral rotors on ground without stopping the main rotor. This additionnal function will considerably improve safety of the environment while the aircraft is waiting on ground. However, this function cannot be ensured by an usual clutching device based on automotive technology due to obvious safety inflight requirement. It can only be done by a positive locking device which has to be specifically invented.
The aim of this CfP is to study, design, manufacture and test a demonstrator of a declutching device that could be integrated in the drive system of the LifeRCraft in order to allow to stop one lateral rotor without stopping the whole dynamic system.

- *Power levels and flow:*

While this system is clutched:

- The power transmitted thought the system will be up to ≈1MW (nominal direction of the power flow).
- The system will have also to deal with negative power flows (going reverse to the nominal power flow) to up to ≈0,4MW.

During synchronization/desynchronization phases, the system will have to transmit a power flow of 50kW to 100kW (linked to inertia and drag resistance of the driven elements).

- *Integration constraints and speed*

According to first partner results in term of system volume / ease for integration / selected technology (results from pre-design phase), the Topic Manager will provide detailed integration constraints and speed requirement.

The nominal speed is expected between 1700 and 3400rpm.

The design has to be optimized in term of external dimensions, weight and unit cost.

Illustration of a declutching device
(only for information - not to be considered as the expected solution)

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
2.6.5.1	Predesign of the declutching system	t0 + 3months
2.6.5.2	Detailed study	t0 + 11months
2.6.5.3	Detailed design	t0 + 20months
2.6.5.4	Manufacture	t0 + 32months
2.6.5.5	Simplified test	t0 + 25months
2.6.5.6	Power bench test	t0 + 32months
2.6.5.7	*Demonstrator integration*	*Nice to have*
2.6.5.8	*Ground test on the demonstrator*	*Nice to have*

Task 2.6.5.1: Predesign the declutching system

Define the different potential concepts of the system starting from functional requirements established by the Topic Manager. Compare the different solutions and assess with the Topic Manager which one is the best candidate to develop.

Task 2.6.5.2: Detailed study

Produce the project definition (3D model). Define the interface drawings.

Build the part substantiation documentation. Analyze the behavior of the system (multi-physic simulation)

Task 2.6.5.3: Detailed design

Produce all the detailed drawings.

Finalize the substantiation documentation.

Task 2.6.5.4: Manufacture

Manufacture all elementary parts in respect to aeronautical quality standard.

Assemble and control the subsystem.

Task 2.6.5.5: Simplified test

Perform simplified test for risk mitigation, eventually finalize solution selection and validate sizing.

Produce the associated test report.

Task 2.6.5.6: Power bench test

Perform full scaled tests representative of the LifeRcraft figures in term of power flow (torque and speed) and environment conditions (ex: temperature).

This power bench test phase will be composed of at least:

- fatigue testing (clutch/declutch cycles)
- endurance testing (> 50 hours)

Produce the associated test report.

NB: According to first partner results in term of system volume / ease for integration / selected technology (results from pre-design phase), the Topic Manager will provide detailed integration constraints, and therefore the environment temperature to take into account during the representative power bench tests.

Task 2.6.5.7: Demonstrator integration

Depending on the result of the previous tasks, it will possible to realise the integration of the declutching device on the demonstrator for a ground test validation.

Task 2.6.5.8: Ground test on the demonstrator

If the test is organised, the partner will have to insure the support to the Topic Manager for the test preparation, the realisation of the tests and the annalysis of the results..

Those two last tasks will be confirmed if a sufficient maturity of the topic is demonstrated and are also strongly dependent of availably of the demonstrator: to be quoted in option.

3. Major deliverables/ Milestones and schedule (estimated)

Deliverables / Outputs			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D.1	3D mock-up	3D	t0 + 3months and t0 + 11months
D.2	Interfaces drawings	Drawings	t0 + 11months
D.3	Parts (or system) substantiation (calculation) documents	Document	t0 + 11months
D.4	Detail study released	Report Drawings	t0 + 11months
D.5	PDR capitalization	Report	Milestone +1 month
D.6	Detail drawings released	Drawings	t0 + 20months
D.7	CDR capitalization	Report	Milestone +1 month
D.8	Quality documentation	Document	t0 + 32months
D.9	Simplified test report	Report	Simplified test +1 month

D.10	Power bench test report	Report	Power bench test +1 month

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M.1	Pre-Project review (PDVR)	Milestone	t0 + 3months
M.2	Preliminary Design Review (PDR)	Milestone	t0 + 11months
M.3	Critical Design Review (CDR)	Milestone	t0 + 20months
M.4	Delivery of test sample	Hardware	t0 + 25months
M.5	Delivery of full scaled system	Hardware	t0 + 32months
M.6	*Delivery for on ground test on demonstrator*	*Hardware*	t0 + 36months

4. Special skills, Capabilities 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. Therefore the Partner has to provide all documentation necessary to achieve permit to fly (in case of integration on demonstrator):

- Providing all 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.
- Harmonization (Topic Manager-Partner) of calculation processes/tools
- Materials, protection, coatings and technologies used for drive system must have the qualification level necessary to achieve a permit to fly (at the date of ….)
- Acting interactive with Topic Manager at any state of work
- Access to the production sites
- 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 until permit to fly phase.
- The Partner has to perform the updates of documentation in case of in-sufficient quality

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 mechanical subsystem for rotorcraft.
- Tools for design and stress analysis in the aeronautical industry (i.e. CATIA v5 release 21, SAMCEF, VPM, Windchill etc.…)

- Capacity and experience in manufacturing parts for rotorcraft drive system
- Capacity to assess and eventually repair “in-shop” components due to manufacturing deviations.
- Capacity and experience to test, to develop and to provide support to rotorcraft subsystem 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 IAW Eco-design rules and requirements.
- Capacity of evaluating results in accordance to Horizon 2020 environmental and productivity goals following Clean Sky 2 Technology Evaluator rules and procedures.
- Experience .with TRL Reviews in research and manufacturing projects for aeronautical industry
- Proved experience in collaborating with reference aeronautical companies within last decades in:
    - Research and Technology programs
- Participation in international R&T projects cooperating with industrial partners, institutions, technology centres, universities and OEMs (Original Equipment Manufacturer).
- Capacity of providing large aeronautical components within industrial quality standards.

Certification:

- 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).
- EASA CS21 DOA and POA are highly suitable.

VII. Enhanced gear strength through cavitation peening technologies

Type of action (RIA or IA)	IA		
Programme Area	FRC		
Joint Technical Programme (JTP) Ref.	WP 2C.6.11 Mobility Discovery		
Indicative Funding Topic Value (in k€)	400		
Topic Leader	GE Avio	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[32]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CFP06-FRC-02-23	**Enhanced gear strength through cavitation peening technologies**
Short description	
The focus of the topic is the development of technologies for enhancing the gear strength, specifically through cavitation peening, on high loaded applications. The applicant shall: • Define the optimal parameters for the cavitation peening process. • Process appropriate T/As through an optimised cavitation peening system • Test the T/A for confirming higher achieved mechanical properties • Determine an appropriate method to identify the cavitation parameters	

[32] The start date corresponds to actual start date with all legal documents in place.

1. Background

The Compound Rotorcraft Demonstrator IADP contributes to the achievement of the Strategic Research and Innovation Agenda (SRIA) and the Flight Path 2050 vision for the EU transportation, introducing an innovative compound rotorcraft concept that combines together airplane and helicopter functionalities. In particular, the project will substantiate the possibility of combining in an advanced rotorcraft the following capabilities: payload capacity, agility in vertical flight including the capability of landing on unprepared surfaces nearby obstacles, load/unload rescue personnel and victims while hovering, long range / high cruise speed, low fuel consumption and gas emission, low community noise impact, and productivity for Operators.

Lifercraft project is aimed at demonstrating that compound rotorcraft configuration opens up new mobility roles that will enable expectations for door-to-door mobility, environmental protection and citizens health and safety, to be met in a way that neither conventional helicopters nor fixed wing aircraft can currently cover while being sustainable for both Operators and Industries.

The LifeRCraft demonstrator will pave the way for the development and marketing of a European compound rotorcraft engine, thus allowing a sustainable growth of EU in this sector to support competitiveness with respect to foreign OEMs that are very active in developing solutions addressing similar requirements.

The LifeRCraft is a compound helicopter: a heavier-than-air aircraft which, in flight, and at slow speed derives the substantial proportion of its lift from a rotary wing system but at speed can generate lifting and longitudinal thrust from a suitable combination of rotary wing system, fixed lifting surface(s) and auxiliary propulsor(s).


Avio Aero role in the Mobility Discovery workpackage is to design, develop and manufacture the lateral propellers and the high-speed input stage.

Avio Aero believes that the proposed project will strongly contribute to the innovation of air transportation. Such innovation is represent mainly by the aircraft architecture itself, for which the mechanical transmission is a key enabler. A particular attention will be focused on acoustic and CO_2 emission targets, that are required to be lower than in current helicopters, as well as on life cycle affordability and eco-friendly technologies, all these representing the main drivers that will set the Mobility Discovery project success.

Weight will represent one of the main concerns in the compound rotorcraft design assessment. In fact, with respect to traditional helicopters, the new configuration also includes wings and propellers as well as higher power engines and an extended drive train, all contributing to an increase in the overall system weight. These elements also may impact on the aerodynamic efficiency that represents a crucial aspect both in cruise and hover/vertical flight operating conditions. The design target will be aimed at minimizing drag forces, optimizing Lift-to-Drag ratio in order to maximize rotorcraft efficiency and maneuverability.

Due to the LifeRCraft configuration and flight principle, torque required by each propulsive/lift system can significantly vary according to the specific operating flight conditions:
• While hovering/vertical flying the maximum power has to be delivered to the Main Rotor, while the lateral rotors provide the conventional anti-torque function.
• While in cruise mode the power to the Main Rotor is reduced since lift is provided mainly by wings, while the Lateral Propellers absorb almost the entire power to provide thrust and anti-torque.
For this reason, the LifeRCraft Mechanical Drive System has to be flexible enough to allow for power transmission in a wide operative range maintaining high level of performance and good dynamic behavior.
Leveraging Avio Aero experience in gearboxes design and manufacture, and thanks to the implementation of innovative technologies developed both inside and outside the Mobility Discovery project, it will be possible to design a high power density drive system capable to allow high performance and to satisfy the restrictive safety and reliability requirements.

In such a context, Avio Aero is willing to develop appropriate technologies, enabling specifically, with this call for proposal, higher strength of gears, using dedicated techniques as the cavitation peening process. In such a process, which is performed under the liquid surface, the component is treated through submerged pressure jets, causing very high compressive residual stresses (up to 30% higher than in conventional shot peening). The process is not prone to cause neither profile, nor hardness modification beneath the surface since no solid object hits the surface[33].

The target values in terms of increase in bending fatigue limit strength expected is at least 12% on cavitation peened vs shot peened gears and 24% with regards to not peened gears[34].

As a risk mitigation feature, the topic manager may be open to further gear strength enhancement techniques, if the cavitation peening is deemed to be ineffective analysing preliminary residual stress profiles and test results, or damaging in terms of alteration of other important relevant gear features parameters. Among the alternative methods, the topic manager can foresee the laser peening process.

2. Scope of work

Gears of the FRC IADP Lateral Gearbox are characterized by a very high load spectra. From here, the need to investigate on innovative peening processes aimed to enhance the gears from the bending fatigue perspective.
The overall aim of the CfP will be to validate the following values in terms of increase in bending fatigue limit strength for cavitation peened gears:

[33] Soyama et al. Comparison between cavitation peening and shot peening for extending the fatigue life of a duralumin plate with a hole, Journal of Materials Processing Technology Volume 227, January 2016.
[34] Soyama et al. Sustainable surface modification using cavitation impact for enhancing fatigue strength demonstrated by a power circulating-type gear tester, International Journal of Sustainable Engineering Volume 3, 2010 - Issue 1: Materials and Sustainable Engineering

- 12% at least vs shot peened gears
- 24% at least vs not peened gears

And to increase the compressive residual stresses by up to 30% with regards to the conventional shot peening process.

The applicant will perform a number of tasks using a phase and gate approach. The topic manger will periodically meet the applicant in person or via teleconference in order to accurately track the evolution of the tasks.

The applicant shall perform the following tasks:

<u>Task 1 – Definition of test plan, Test Article (T/As) and rig preparation</u>

<u>T1.1 Test articles and plan definition</u>

Design data (size, stresses) and operative conditions of the gears applied on the lateral gearbox are still under refinement, but will be available and provided to the applicant at the activity starting date.

As reference the following design data and operative conditions can be considered:

- Expected diameter of the gear is between 270 mm and 350 mm
- Expected conditions in the ranges below :

Temperature:	80° - 160°C
Rotational speed:	1000 - 2000 rpm
Torque:	5000 - 7000 Nm
Oil:	NATO O-155 Min OIL 8cSt or NATO O-148 Synt OIL 3-3,5 cSt or MIL23699P

In the target design the material of the gear will be high strength carburizing steel.

Taking into account those needs, the applicant and the topic manager will define jointly a target residual stress profile for the IADP gears. It is foreseen to increase the compressive residual stresses by up to 30% with regards to the conventional shot peening process.

In order to validate the effects of the above residual stress profile on the bending fatigue limit, three campaigns of testing are foreseen:

1. Rotating bending fatigue on notched carburized specimen
2. Bending Fatigue on carburized gears in HCF
3. Scuffing risk assessment on carburized gears

The first testing campaign is designed for assessing the effectiveness of the residual stress addition to the stress profile gradient for bending strength increase; therefore the specimens will reproduce the notched stress profiles similar to those of gears.

For the second and third campaign, the applicant shall define the gear T/A design, the test plan and eventual rig features that shall be needed for the processed gear validation.

Carburized gears will have to be tested for bending and scuffing resistance, therefore different geometries can be potentially used in order to trigger the two aspects taking into account the representativeness for the IADP gears.

The following information shall be available to the topic manager:

- Number of specimen and gears T/A to be tested
- Type of test (e.g. single component, meshing components)
- Loading type (load, torque), magnitude and cycle
- Oil inlet temperature, speed, lubrication condition
- Pass/fail criteria

The topic manager will approve the T/A design and test plan.

T1.2 T/A manufacturing and procurement

The applicant is responsible for the procurement of the test articles, i.e. the following three sets:

- Notched carburized specimen, designed for rotating bending tests
- Carburized gears designed for bending
- Carburized gears designed for scuffing risk

The manufacturing phase of this task will end before performing the special peening process on the T/A surface, as the optimized process parameters will be defined in T2.1 – T2.3.

T1.3 Test rigs modifications and commissioning

Due to the planning of testing activities, the test rigs have to be accordingly prepared and adapted (or procured) by the applicant in order to be able to reach bending failure or scuffing failure on T/A. This will include a static commissioning phase.

Task 2 – Cavitation peening process development

T2.1 Process parameters setup for T/A by analysis

The applicant shall be able to preliminary set, by a physics-based numerical tool, the effect of cavitation peening on carburised specimen.

In order to produce the adequate waterjet, the numerical tool shall be able to correlate the waterjet parameters (e.g. pressure, flow, orientation, etc.) to the residual stress profile underneath the specimen or gear surface.

T2.2 Cavitation peening system adaptation to T/A

The applicant shall be able to adapt a cavitation peening system in order to treat specimens and gears accordingly to the parameters setup in the previous tasks.

T2.3 Process trials on specimen

The applicant shall test the process parameters on specimens, in order to analyse the main parameters of the un-peened vs peened components under the surface, specifically:

- Hardness profile
- Residual stress profile (both directions)
- Roughness

- Metallurgical structure

T2.4 T/A processing

The applicant will treat the gear T/As in order to obtain the adequate design (only part of the T/A set will be enhanced, and the rest will not).

Un-peened vs peened component analysis will be performed in order to characterise the following parameters under the surface:

- Hardness profile
- Residual stress profile (both directions)
- Roughness
- Metallurgical structure

The topic manager will approve finally the T/A features.

T2.5 Process tuning

The phase is characterized by iteration on the cavitation peening process for enacting the desired residual stress profile, and therefore appropriately tuning the simulation software. As a constraint for the task, the roughness, hardness and other design objectives will have to be within tolerances.

Task 3 – Testing phase on cavitation peened components vs. non

T3.1 Specimen testing

In order to minimize the economic impact of process tuning on the actual test articles, a set of preliminary test will be performed on subscale specimen, where the rotating bending fatigue characteristics will be analysed with regards to the residual stress profile. Back to back test will be performed on non-peened vs peened specimen.

As a risk mitigation feature, the topic manager may be open to further strength enhancement techniques, if the cavitation peening is deemed to be ineffective analysing test results, or too damaging in terms of alteration of the classical design parameters, as roughness, hardness, etc. Among the alternative methods, the topic manager can foresee the laser peening process.

T3.2 Bending strength test on test articles

In this phase, the bending fatigue strength characteristics will be analysed with regards to the residual stress profile. Back to back test will be performed on non-peened vs peened gears. A sufficient number of gears (at least 2x12 sets) has to be tested in order to statistically characterise the two subsets (classical, and enhanced) determining whether there is an actual fatigue strength increase.

A dedicated commissioning phase is asked to the applicant in order to avoid to perform the test in rotational ranges prone to dynamic load increase.

At the end of the test, the applicant shall produce a report with the results of the tests, the failures characterisation (metallography, hardness profile, etc.) and estimate of the strength level.

T3.3 Scuffing power circulating test on test articles

In this phase, the scuffing resistance characteristics will be analysed with regards to the residual stress profile. Back to back test will be performed on non-peened vs peened specimen. A sufficient number of gears (at least 2x12 sets) has to be tested in order to statistically characterise the two subsets (classical, and enhanced) determining whether there is an scuffing risk change.

A dedicated commissioning phase is asked to the applicant in order to avoid to perform the test in rotational ranges prone to dynamic load increase. High oil inlet temperature (T > 120°C) testing is needed to examine scuffing risk mitigation.

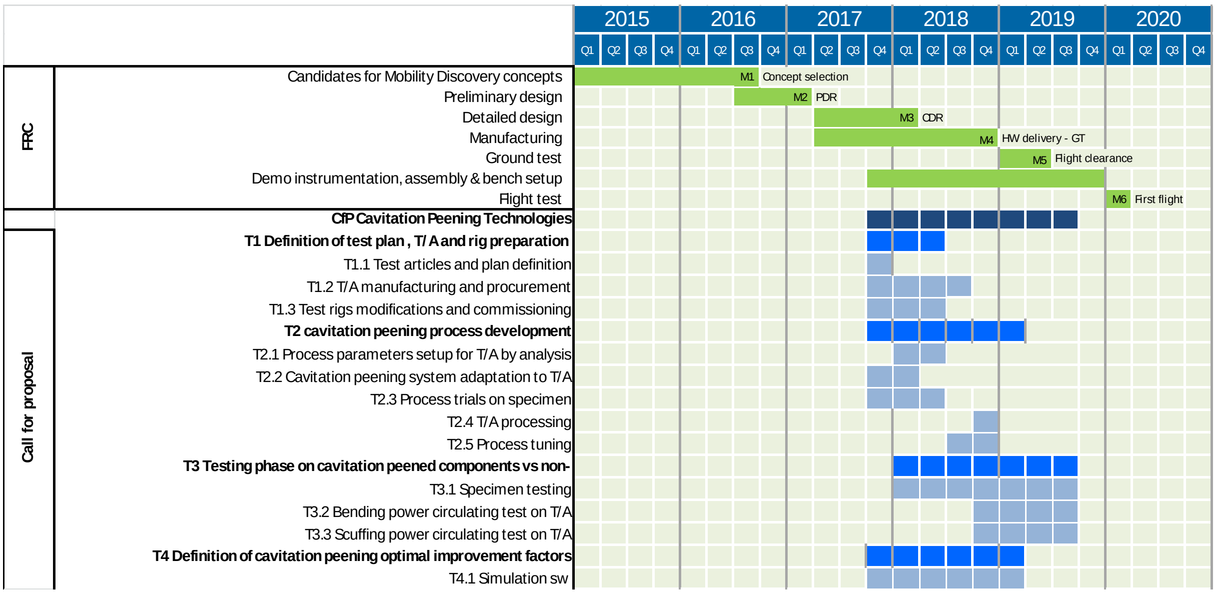
At the end of the test, the applicant shall produce a report with the results of the tests, the failures characterisation (metallography, hardness profile, etc.) and estimate of the risk level.

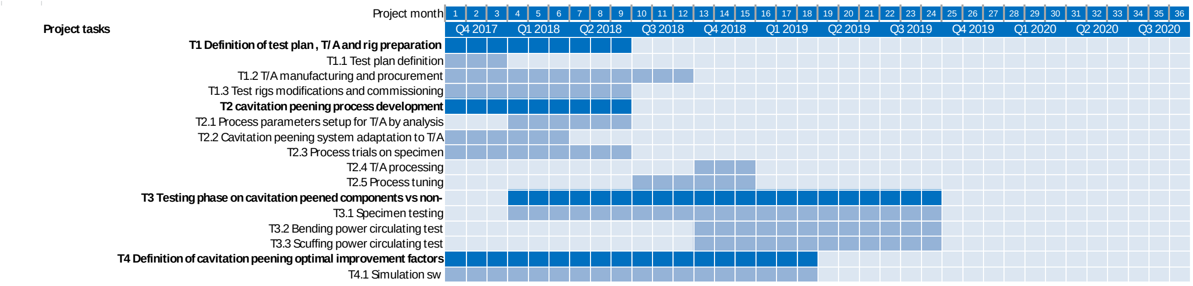
Task 4 – Definition of cavitation peening optimal improvement factors

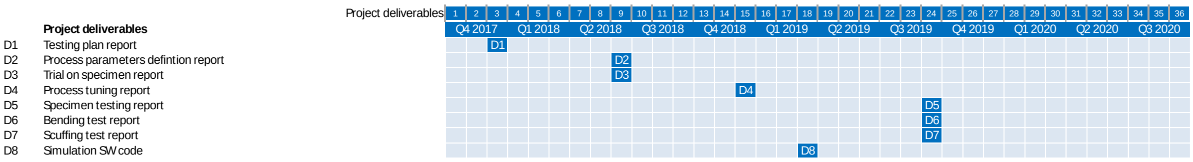
T4.1 Simulation SW development

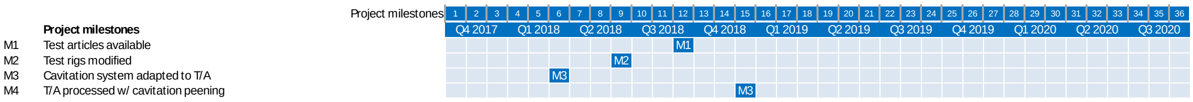
The applicant will develop a comprehensive numerical tool able to correlate the waterjet features and parameters (nozzle size, angle, flow, pressure, etc.) to the residual stress obtainable on the actual parts, and superimposing it to the actual stress during meshing, correlating to the actual failures observed in the bending failure task. The SW has to be developed without open-source codes.

Schedule for Topic Project (Level 2 Gantt):









3. Major deliverables/ Milestones and schedule (estimate)

	Deliverable	Timing (TO=KoM)
D1	T/A Design and Testing plan report	TO+3 months
D2	Process parameters definition report	TO+9 months
D3	Trial on specimen report	TO+9 months
D4	Process tuning report	TO+15 months
D5	Specimen testing report	TO+24 months
D6	Bending test report	TO+24 months
D7	Scuffing test report	TO+24 months
D8	Simulation SW Code	TO+18 months

	Milestone	Timing (TO=KoM)
M1	Test articles available	TO+12 months
M2	Test rigs modified	TO+9 months
M3	Cavitation system adapted to T/A	TO+9 months
M4	T/A processed w/ cavitation peening	TO+15 months

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 management.

Special Skills

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

Proven experience in development of cavitation process for achieving better structural properties.

Proven experience in process simulation on components.

Proven experience in fatigue testing (specimen, gear testing).

The Applicant needs to demonstrate to be in the position to have access to the process and test facilities required to meet the Topic goals.

Experience in aerospace R&T and R&D programs.

Special Skills:

- Experience in Supply Chain management (for T/As procurement)
- Experience in experimental testing and Statistical Methodologies (for Test Plan definition and execution).

Certification:

- N/A

VIII. Hybrid bearing technologies

Type of action (RIA or IA)	IA		
Programme Area	FRC		
Joint Technical Programme (JTP) Ref.	WP 2C.6.11 – Mobility Discovery		
Indicative Funding Topic Value (in k€)	600		
Topic Leader	GE Avio	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[35]	Q1 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CFP06-FRC-02-24	**Hybrid bearing technologies**

Short description

The focus of the CfP is the development of hybrid tapered bearings (Si_3N_4 tapered rollers having steel inner and outer races) for aerospace application.
The main areas of analyses will be:

- the comparison of all steel vs. ceramic bearings in clean and contaminated conditions (through subscale and full scale testing)
- the investigation on allowable contact limits
- the investigation on the critical defects
- the optimisation of the heat to oil characteristics
- the investigation on oil off behaviour

[35] The start date corresponds to actual start date with all legal documents in place.

1. Background

The Compound Rotorcraft Demonstrator IADP contributes to the achievement of the Strategic Research and Innovation Agenda (SRIA) and the Flight Path 2050 vision for the EU transportation, introducing an innovative compound rotorcraft concept that combines together airplane and helicopter functionalities. In particular, the project will substantiate the possibility of combining in an advanced rotorcraft the following capabilities: payload capacity, agility in vertical flight including the capability of landing on unprepared surfaces nearby obstacles, load/unload rescue personnel and victims while hovering, long range / high cruise speed, low fuel consumption and gas emission, low community noise impact, and productivity for Operators.

Lifercraft project is aimed at demonstrating that compound rotorcraft configuration opens up new mobility roles that will enable expectations for door-to-door mobility, environmental protection and citizens health and safety, to be met in a way that neither conventional helicopters nor fixed wing aircraft can currently cover while being sustainable for both Operators and Industries.

The LifeRCraft demonstrator will pave the way for the development and marketing of a European compound rotorcraft engine, thus allowing a sustainable growth of EU in this sector to support competitiveness with respect to foreign OEMs that are very active in developing solutions addressing similar requirements.

The LifeRCraft is a compound helicopter: a heavier-than-air aircraft which, in flight, and at slow speed derives the substantial proportion of its lift from a rotary wing system but at speed can generate lifting and longitudinal thrust from a suitable combination of rotary wing system, fixed lifting surface(s) and auxiliary propulsor(s).


Avio Aero role in the Mobility Discovery workpackage is to design, develop and manufacture the lateral propellers and the high-speed input stage.

Avio Aero believes that the proposed project will strongly contribute to the innovation of air transportation. Such innovation is represent mainly by the aircraft architecture itself, for which the mechanical transmission is a key enabler.

A particular attention will be focused on acoustic and CO_2 emission targets, that are required to be lower than in current helicopters, as well as on life cycle affordability and eco-friendly technologies, all these representing the main drivers that will set the Mobility Discovery project success.

Weight will represent one of the main concerns in the compound rotorcraft design assessment. In fact, with respect to traditional helicopters, the new configuration also includes wings and propellers as well as higher power engines and an extended drive train, all contributing to an increase in the overall system weight. These elements also may impact on the aerodynamic efficiency that represents a crucial aspect both in cruise and hover/vertical flight operating conditions. The design target will be aimed at minimizing drag forces, optimizing Lift-to-Drag ratio in order to maximize rotorcraft efficiency and maneuverability.

Due to the LifeRCraft configuration and flight principle, torque required by each propulsive/lift system can significantly vary according to the specific operating flight conditions:
• While hovering/vertical flying the maximum power has to be delivered to the Main Rotor, while the lateral rotors provide the conventional anti-torque function.
• While in cruise mode the power to the Main Rotor is reduced since lift is provided mainly by wings, while the Lateral Propellers absorb almost the entire power to provide thrust and anti-torque.
For this reason, the LifeRCraft Mechanical Drive System has to be flexible enough to allow for power transmission in a wide operative range maintaining high level of performance and good dynamic behavior.
Leveraging Avio Aero experience in gearboxes design and manufacture, and thanks to the implementation of innovative technologies developed both inside and outside the Mobility Discovery project, it will be possible to design a high power density drive system capable to allow high performance and to satisfy the restrictive safety and reliability requirements.

In such a context, Avio Aero is willing to develop appropriate technologies, enabling not only the above high power density CTQ, but also a very low heat to oil capability and high oil-off performance. The general use of hybrid bearings (ring: steel, rollers: Si_3N_4) is therefore a must. Among the various types of bearing geometries, the tapered roller bearing is vastly applied and its behavior is less known in its hybrid form; therefore it has to be fully optimized with regards of its reliability and high efficiency. The target of this Call for Proposal is aiming to such increase of knowledge paired with feature optimization.

2. Scope of work

The applicant will perform a number of tasks using a phase and gate approach. The topic manger will periodically meet the applicant in person or via teleconference in order to accurately track the evolution of the tasks.
The applicant shall perform the following tasks:

Task 1 – Definition of Test plan, T/A and rig preparation

T1.1 Test plan definition

Design data and operative conditions of tapered bearing applied on the lateral gearbox are still under refinement, but will be available and provided to the applicant at the activity starting date.
As reference the following design range and operative conditions can be considered:

- Expected diameter of the gear is between 270 mm and 350 mm
- Expected conditions in the ranges below :

  Temperature: 80° - 160°C (when lubrication is present); more than 180° (oil off)

Radial load: 20 - 80 kN

Axial load; dependent upon bearing design

Oil: NATO O-155 Min OIL 8cSt or NATO O-148 Synt OIL 3-3,5 cSt or MIL23699P

In the target design the material of the roller will be Si_3N_4; the class of material has to be defined in concurrence with the topic manager. The target design of the rings material is M50 or M50Nil. The heat treatment process will be discussed with the topic manager.

A list of tapered bearings that will be part of the gearbox design, their detailed load spectra, precise dimensions and other characteristics will be provided by the topic manager to the applicant.

Using that information, the applicant will prepare a comprehensive test plan determining the best methods to determine the reliability of bearing in the following representative conditions:

1) clean roller contact
2) contaminated bearing
3) roller defects
4) propagation of spall on roller / raceways defects
5) allowable fatigue limit determination

The applicant shall analyse the possibility of the usage – for test purposes – of either:

- one of the gearbox design bearings, down-selected for its representativeness
- a dedicated representative subscale bearing

Either selection has to be substantiated and approved by the topic manager.

The applicant is asked to propose a plan including back-to-back testing of hybrid bearings (steel rings and Si_3N_4 rollers) vs all steel bearings.

The test plan will have to be performed under responsibility of the applicant, if necessary developing new typologies of tests and/or modifying test rigs already available to the applicant, and producing dedicated test articles.

The following design data of the test articles shall be available to the topic manager:

- detailed inner and outer raceways size, taper angle, curvature, roughness, hardness, case depth, residual stress profile, microstructure, fillet radius(es)
- raceways coatings and advanced texturation (if necessary)
- overall bearing width
- inner diameter of inner ring
- the roller number, diameter, width, hardness, density, elastic modulus and curvature profile, taper angle, fillet radius
- in case of Si_3N_4 rollers: porosity, fracture toughness, bend testing limit, inclusions density tolerance band, fluorescent penetrant inspection acceptable indication limit
- cage size, its guiding diameter, the cage slot size and material characteristics (density, other mechanical expected properties)
- backshoulder dimensions, local radius, five roughness and texturation

For the above mentioned test bearings, in each of the campaign conditions the following information has to be provided:

- calculated resulting pressure profiles on each contact interface (inner ring vs roller, outer ring vs roller, roller vs backshoulder) and local lubrication conditions (lambda ratio)

- running speed and load, temperature
- procedure of induced contamination on bearing (including size and type of contaminants)
- procedure of induction of defects on rollers
- pass / fail criteria (i.e. runout time, failure conditions)
- number of test articles

The test plan will deploy a set of test articles with a sample appropriate to statistically identify the behaviours of the different typologies (steel vs hybrid design), upon previous applicant experience on steel vs hybrid design.

The test plan and the test article design will have to be approved by the topic manager.

T1.2 Test articles manufacturing and procurement

The applicant, upon approval of the test plan deliverable by the topic manager, will manufacture and/or procure the test articles for the whole test activities of the CfP under its own responsibility, providing evidence to the topic manager of the conformity of the batch.

T1.3 Test rigs modifications and commissioning

The applicant, upon approval of the test plan deliverable by the topic manager, will eventually modify and adapt the appropriate rigs and/or part of rigs for performing the whole test campaign, providing evidence to the topic manager of the modifications.

Task 2 – Testing phase comparing hybrid bearing vs all steel bearing

T2.1 Clean oil testing

The applicant, under topic manager supervision, will perform the appropriate test campaign defined in T1.1 for analysing the behaviour, in clean fatigue conditions, of the hybrid bearings vs all steel bearings.

T2.2 Induced defects /debris ingestion

The applicant, under topic manager supervision will perform the appropriate test campaign defined in T1.1 for analysing the behaviour, in a condition that will reproduce two relevant conditions:

- debris-indented roller bearing
- roller defect

The above conditions will be realized through a method proposed by the applicant and approved by the topic manager, for example through artificial raceway indenting, debris ingestion, laser indentation on the ceramic rollers surface, etc.

T2.3 Spall and defects propagation

The applicant, under topic manager supervision will perform the appropriate test campaign defined in T1.1 for analysing the behaviour of the evolution of spall nucleated during previous phases and defects induced in the bearing rollers. This would be realized through a method proposed by the applicant and approved by the topic manager.

T2.4 Fatigue limit allowable testing

The applicant will appropriately test a set of bearings in order to provide a contact fatigue allowable limit, in conjunction with calculation method set in another task, following an appropriate test campaign defined in T1.1.

The fatigue limit is herein defined as the contact stress level that will not cause fatigue initiation within the defined test plan in T1.1.

The data regarding the bearing under test detailed below will have to be communicated to the topic manager.

Task 3 – Lubrication and heat to oil optimisation

T3.1 Bearing Design optimisation for lubrication and oil-off

Since the tapered roller bearing will inherently be supported also through the back shoulder, where a sliding kinematic will be present, the applicant will develop a bearing design that will reduce the sliding heat production using advanced methodologies for developing the most efficient film lubrication (through local profile modifications, surface texturing, coatings, etc) at various speeds. Also, the cage/cage guiding surface contact and the cage/roller interactions shall also be considered. The applicant shall also determine the best oil-free contact design and – in accordance with the topic manager – will eventually perform a trade-off for the design characteristics.

T3.2 Roller and ring process optimisation for minimal heat-to-oil

The applicant will manufacture a set of bearing including the low-loss design package, developed in T3.1; the bearing set(s) will be used for appropriate test campaign.

T3.3 Heat to oil and effect of oil loss test

The applicant will measure the heat generation due to the bearing rotation under load at different temperatures and evaluate the power loss, comparing it to the one generated by a non-optimised bearing in lubricated conditions. Steady and transient conditions effects on parasitic torque and heat generation shall be measured. Measurement of power loss shall be precise enough to statistically distinguish the difference in power losses between optimised and non-optimised bearings.

Further, comparative oil off testing (each interruption 2h-4h duration ca.) shall be performed, measuring appropriate physical parameters, as temperature, parasitic torque, vibrations, etc. The oil off test details will be approved by the topic manager in order to be representative to the module test.

Task 4 – Optimised life calculation model

T4 Life calculation model

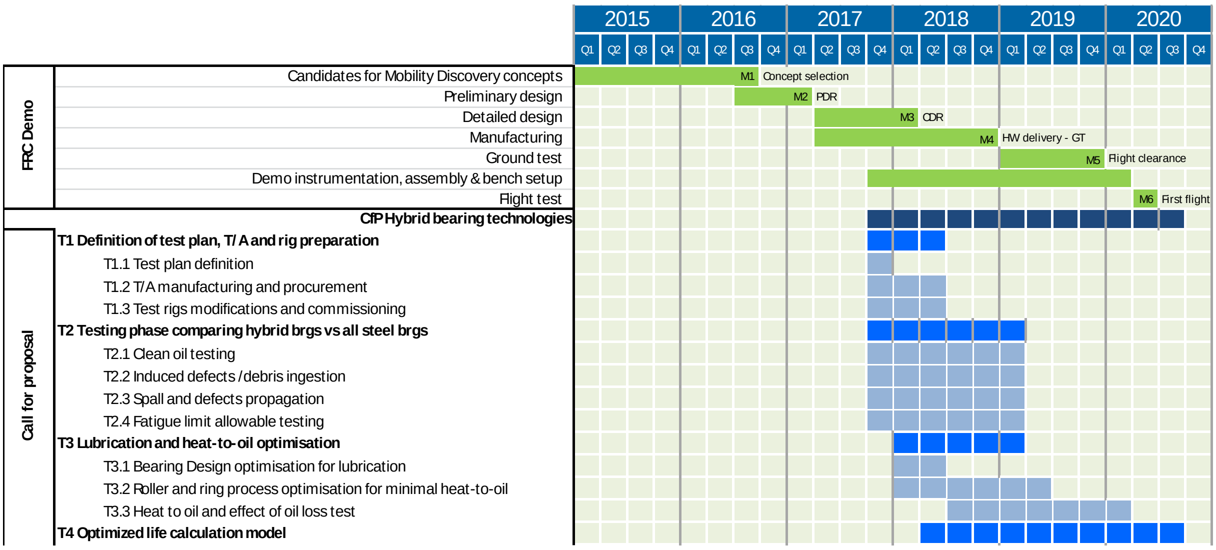
The applicant shall provide to the topic manager a method to analyse the bearing life that will be used for checking the reliability of a tapered roller bearing design, taking into account spectra of load, speed, temperature, etc.

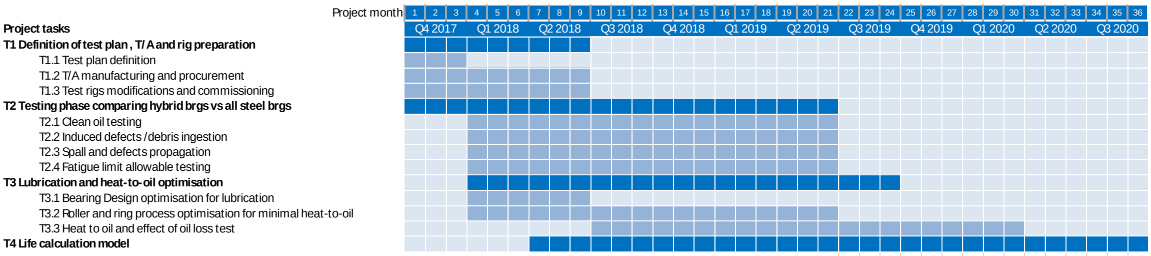
Data that will be used for the model will be:

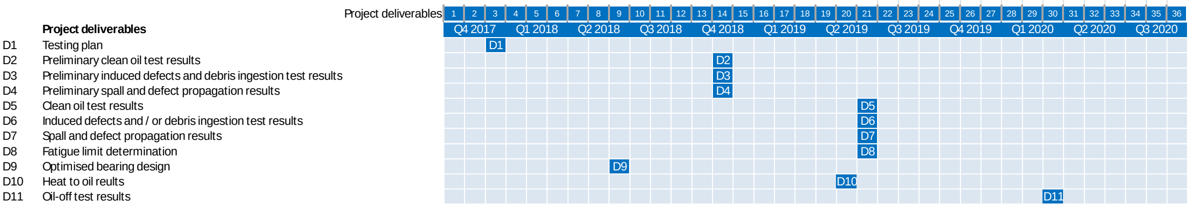
- detailed inner and outer raceways size, taper angles, curvature, roughness, hardness, case depth, residual stress, microstructure
- raceways coatings and advanced texturation (if necessary)
- overall bearing width
- inner diameter of inner ring
- the roller number, diameter, width, hardness, density, elastic modulus and curvature profile. In the calculation, the user may select roller material shall be either steel or Si_3N_4 material base.
- Inner and outer ring shall be in M50 or M50Nil
- the cage size, its guiding diameter, the cage slot size and material characteristics (density, other mechanical expected properties)
- back shoulder dimension and advanced texturation (if necessary)

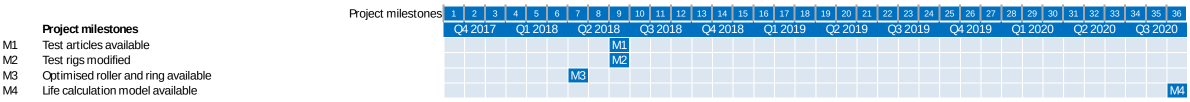
The model results will be consistent with the testing campaign results.

Schedule for Topic Project (Level 2 Gantt):









3. Major deliverables/ Milestones and schedule (estimate)

	Deliverable	Timing (T0=project start date
D1	Testing plan	T0+3 months
D2	Preliminary clean oil test results	T0+14 months
D3	Preliminary induced defects and debris ingestion test results	T0+14 months
D4	Preliminary spall and defect propagation results	T0+14 months
D5	Clean oil test results	T0+21 months
D6	Induced defects and / or debris ingestion test results	T0+21 months
D7	Spall and defect propagation results	T0+21 months
D8	Fatigue limit determination	T0+21 months
D9	Optimised bearing design	T0+9 months
D10	Heat to oil reults	T0+20 months
D11	Oil-off test results	T0+30 months

	Milestone	Timing (T0=project start date
M1	Test articles available	T0+9 months
M2	Test rigs modified	T0+9 months
M3	Optimised roller and ring available	T0+7 months
M4	Life calculation model available	T0+36 months

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 management.

Special Skills

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

Extensive experience in development of ceramic bearings for high performance aerospace application. Proven experience in aerospace bearing development for equivalent applications.

Proven experience in tapered ceramic roller bearings manufacturing in industrial sector; experience in tapered ceramic roller bearings manufacturing in aerospace sector would be an asset.

Successful experience, with demonstrable benefits, of application of innovative technologies to gear shafts is an additional asset. Availability of technologies at an high readiness level to minimize program risks is an asset.

The Applicant needs to demonstrate to be in the position to have access to the test facilities required to meet the Topic goals.

Experience in aerospace R&T and R&D programs.

Special Skills:

- Experience in Supply Chain management (for T/As procurement)
- Experience in experimental testing and Statistical Methodologies (for Test Plan definition and execution).

IX. Fuel System Detail Development, Testing and Manufacturing

Type of action (RIA or IA)	IA		
Programme Area	FRC		
Joint Technical Programme (JTP) Ref.	WP 2.7.6 Fuel System		
Indicative Funding Topic Value (in k€)	1500		
Topic Leader	Airbus Helicopters	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	60	**Indicative Start Date**[36]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CFP06-FRC-02-25	**Fuel System Detail Development, Testing and Manufacturing**
Short description	
Development, testing and manufacturing of a fuel system for a high speed compound helicopter, comprising engine feeder subsystem, fuel transfer system and ventilation system comprising optimization of the ventilation outlets, integration of capacity gauging system and development of an innovative optical Fuel Level sensor. Furthermore Fuel Test rig Design, Manufacturing and Installation on the existing Universal Test Rig Platform at the OEM.	

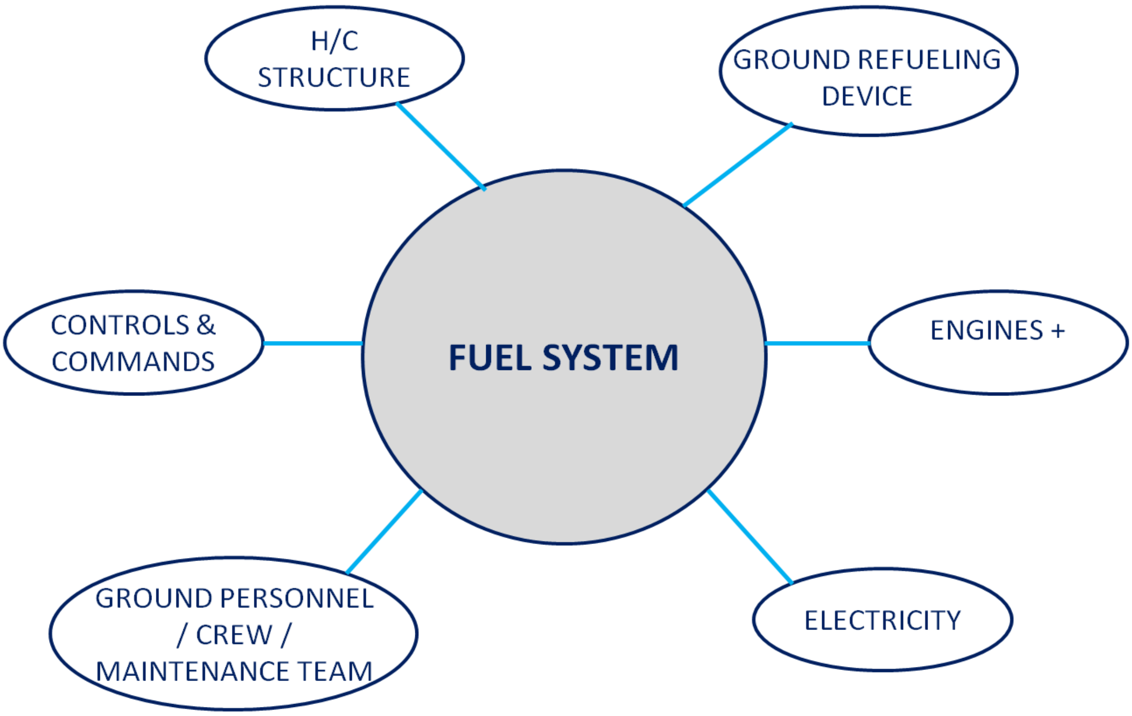
[36] The start date corresponds to actual start date with all legal documents in place.

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 Program, 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 of the Fuel System including an innovative optical Fuel Level Sensor for the High Speed Compound Helicopter and designing of a Fuel Test Rig, Manufacturing and Installation for the OEM. The Substantiation for the Permit to Flight (PtF) of the ITD shall be provided to the Topic Manager (Documentation and Test Reports)



Scheme: Fuel System Interactions

a) **Detail Development and Manufacturing of the Fuel System consists the following Activities**

- Final Sizing of the Fuel System
- Final Selection of Purchasing Parts of the Fuel System
- Selection of the Optical Sensor, Gauging Installation Tests with the Optical Sensor
- Preparation of the Manufacturing, Installation and Equipment Drawings
- Preparation of the Fuel Test Rig Drawings
- Preparation of the Certification Test Plan and Program with the Topic Manager
- Manufacturing and Purchasing of the Fuel System Components,
- Preparation of the Substantiation documentation for the "Permit to Flight Certification" and providing Technical Data and descriptive documentation for the Demonstrator Operation
- Supporting the Final Assembly Line for the Fuel System Installation and Testing on Aircraft
- Supporting the Demonstrator Flight Campaign with Technical Support and Spare Parts

b) **Fuel Test Rig Installation and Testing**

The required tasks for the Fuel System Rig with the installed with the RC Fuel System

- Providing the Design documentation for the Rig Installation
- Manufacturing and Purchasing of the RC Fuel System Components for the Fuel Rig
- Preparation and Testing the following functions for the RC Fuel System
    - Pressure Refueling and Gravity Refueling Function
    - Balancing Function, Fuel Transfer Function
    - Testing and Installation of the Optical Sensor
    - Installation and Testing of the Fuel Gauging System
    - Fuel Commands, Failure Behavior and Display in the cockpit (Interface to the Avionic)
    - Display of the Fuel Quantity in the Cockpit (Interface to the Avionic)
    - Supporting the Flight Test and Permit to Flight preparation

The Basic Universal Fuel Rig in Donauwörth will be used and customized with RC Fuel System components. The Fuel System Bladder and Interconnection will be provided by the partner already in charge of this topic (previous Call).

c) **Fuel System Main Functions**

The main functions of the fuel system are:

- Fuel storage
- Venting System
- Fuel transfer
    - Fuel scavenge
    - Inter-group
- Engine fuel supply

- Refueling (Gravity and Pressure Refueling)
- Drainage
- Fuel electronic control and indicating

The function and performance of all Fuel System components shall be harmonized with the Topic Manger.

- **<u>Fuel storage</u>**

Main function of this subsystem is to provide recipient to store the fuel quantity necessary to perform H/C mission.

- **<u>Air ventilation system</u>**

The function of the venting system is to equilibrate air pressure between the internal of the tanks and the outside of the aircraft to prevent tanks crushing or blister.

- **<u>Transfer system</u>**
  - **<u>Fuel scavenge</u>**

The main purpose of this subsystem is to ensure that feeder tanks remain full with fuel up to the moment when the storage tanks become empty. There are two feeder tanks (tank 4 and 5). Each feeder tank has its own independent fuel collection system. In each group the fuel collection for the engine is ensured by one booster pump, two jet pumps and the associated piping are required.

The jet pumps that are installed in the feeder tanks are designed to scavenge the quantity of fuel required by the engine consumption under AEO Take-Off-Power condition. The motive flow that is necessary for the operation of the jet pumps is provided by their respective pumps installed inside the feeder tanks.

- **<u>Main engine fuel pump</u>**

Each feeder tank is equipped with one supply pump. The supply pump is a booster pump of the brushless type. The pumps are equipped with a canister to ease maintenance and repair tasks: fuel pump cartridge can be removed without draining the fuel tanks.

- **<u>Transfer jet pumps</u>**

Transfer jet pumps are purely mechanical device without any moving part. Their working principle is based on the venturi effect.

- **<u>Piping</u>**

The types and sizes of pipes are determined after Flowmaster analysis and harmonized with the Topic Manger

- **<u>Refueling</u>**
  - **<u>Gravity refueling</u>**

The gravity refueling allows to put requested quantity of fuel inside tanks on ground

The fuel system is equipped with one gravity port per fuel tank group. Each gravity port is composed of a boby, a filter and a cap.

- **Pressure refueling**

The pressure refueling system shall:

a. Be able to refuel the necessary quantity of the Fuel . The Refulling time will be harmoized with the Topic Manager

b. Be able to defuel Defuel by suction on ground

Through a single pressure refueling port the operator is able to refuel the two groups of tanks.
There are principally two pipelines diverging from the single port, one dedicaded to refueling each group of tanks. The pressure refueling system is designed to fill the tanks closest to the feeder and the feeder tanks itself first. In group 1 the fuel is transferred from the pressure line outlet through the flapper valves to tanks 2 and tank 4. In group 2 the tanks 6 and 7 are higher due their geometry and therefore the tanks 3 and 5 are full followed the tanks 6 and 7.

- **Fuel and water drainage**

Each fuel tank is equipped at its lowest point with a water drain valve to permit drainage of settled water.

The water drain valve is of the mechanical type. Its working principle is based on a piston which is spring loaded.

- **Fuel electronic control and indication**

The main functions are:

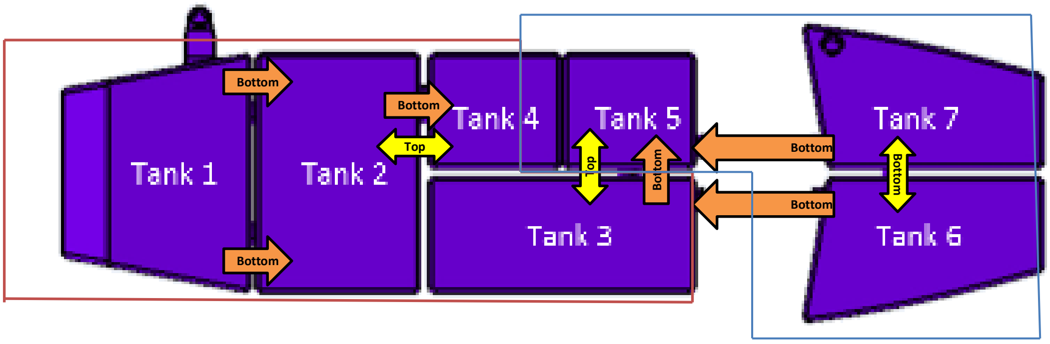
- To provide raw data that is then used to inform crew regarding usable fuel quantity in each tank and fuel temperature
- To provide signals that are then processed in order to warn the crew when the remaining usable fuel quantity in the associated feeder tank is at low level warning
- To provide high level signal to the avionics that are the processed to stop pressure refueling when full refueling is done.

Detailed Function, Fuel System Commands and to be applied Use Cases shall be delivered by the topic manager.

Fuel system allocation	Means	Rationale
Fuel tanks	Flexible Storage Fuel Bladders Flexible Feeder Fuel Tanks	Fuel shall be contain in crashworthy tanks with crashworthy chimneys for intercommunications
Venting system	Vent lines / Vent valve / Vent grids /	Limit pressure differential between inside tanks

	Expansion volumes	and external H/C atmosphere; Fuel containment in roll over situation; Airspace 2%
Engine supply system	Booster pumps / Fuel Shut-off valves	Engines need to be supplied and need an independent device to shut-off fuel supply
Fuel scavenge system	Pumps (e.g. Jet pumps) / Flap valves	Feeder tanks shall be fed to remain full until storage tanks are empty
Intergroup fuel transfer system	Pumps	Fuel flow in several directions for fuel distribution in groups
Refuel/Defueling system	Filler ports / EPRSOV / High level devices / Pressure relief valve	Interface for refuelling/defueling truck connection. Possible automatic stop of pressure refuelling/defueling Means of protection against structural damage
Draining system	Tanks recess Canisters Water drain valves	Tanks capability for water accumulation and containment and interface with H/C outside for GSE connection
Fuel management system	HLD / LLD Gauges / Pressure transmitter / Fuel compensator / Temperature sensor	Measurement for H/C health management and operational status

Fuel Mechanical Equipment	**Included/Not Included**
Fuel Transfer Jet Pumps, Fuel Pumps	Included
Starting Ejectors	Included
Control Valves, Fire Shut of Valves, No Return Valves, Drain Valves, Fuel Valves	Included
Gravity Refuelling System	Included
Pressure Refuelling System	Included
Measuring System	
Fuel Gauging Sensor, Low Level Sensor, High Level Sensor	Included
Innovative Optical Sensors	Included, Parallel installed in the feeder tanks
Piping System	
Feed, Venting System and Fuel Lines	Included
Storage System	
Storage and Feeder Fuel Bladder	Not included (separate Partner)
Equipment Plates	Not Included
Gravity Refuelling Port, Pressure Refuelling Port, Pressure Relief Valve	Included
Intercommunication Pipes	Not included (separate Partner)
Expansion Tank	Not Included (separate Partner)



Bottom	Bottom interconnection equipped with flap valve
Top	Top interconnection

The Fuel tanks are gathered into two groups. The two groups are defined hereafter:

	Group 1	Group 2	Function
Tank 1	x		Storage tank
Tank 2	x		Storage tank
Tank 3		x	Storage tank
Tank 4	x		Feeder tank
Tank 5		x	Feeder tank
Tank 6		x	Storage tank
Tank 7		x	Storage tank

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T1	Architecture Validation, Detail Development, layout, design and certification for PtF of for the High Speed H/C. (Preliminary Fuel System Architecture to be delivered by the by the TM) Fuel System • Fuel Flow Analysis, • Light weight design, • Sizing of the Fuel System for the CDR • Release of the Production and Equipment Drawings • Selection of the Optical Sensor. Providing the Installation and Integration concept. Fuel Rig • Design of the Fuel Rig Components adapted to the Universal Fuel Test Rig at OEM. • Drawing Release of the Fuel Test Rig Fuel Level Sensor (Optical Fuel Sensor) Selection ➔ CDR Fuel System	T0+ 10 months
T2	Manufacturing of the Fuel Test Rig Components completed	T0 + 18 months
T3	In-service of the Fuel Test Rig with the Optical Sensor	T0 + 20 months
T4	Manufacturing of the Fuel System completed	T0 + 22 months
T5	Installation of the Fuel Components	T0 + 23 months
T6	Start support to assembly	T0 + 24 months
T7	Provide Contribution to obtain permit to flight documentation for the Fuel System (final contribution)	T0 + 35 months
T8	Contributing to flight test campaign if needed, cost are to be considered by partner as risk mitigation	T0 + 37 months
T9	Supporting the Flight Test Campaign	Until T0+ 60 months

General remarks:

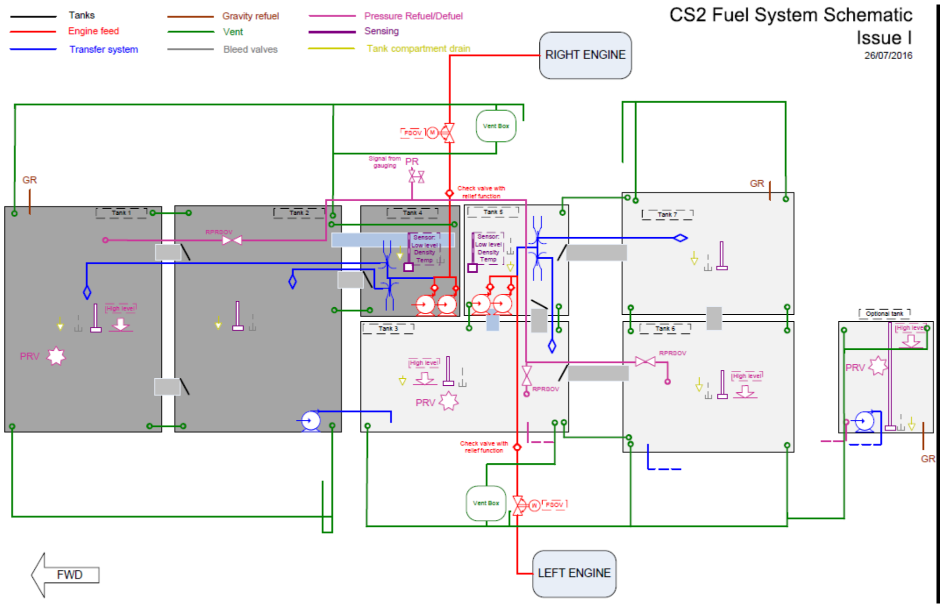
- The architecture of the Fuel System will be done in close cooperation with the Topic Manager.
- The development of the Fuel System and the Fuel System Rig components (Sizing dimensions,

interfaces, etc) has to be done in close cooperation with the Topic Manager and the AHg Rig Fuel Rig Test Team. The Fuel Rig Test will be operated by the by the Topic Manager

- The interfaces to the adjacent structural elements (e.g. Canopy, Fuselage structure, Electrics, Power Plant, Avionics etc.) must be designed in close cooperation with the partner responsible for these elements.
- 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 the CS29.

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

Schematic of the Fuel System



3. Major deliverables/ Milestones and schedule

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D 1	Architecture validation	Doc	T0+6 months
D 2	CDR	Doc	T0+10 months
D 3	Rig test results	HW	T0+20 months
D 4	Delivery of fuel system components	HW	T0+22 months
D 5	Test and “Permit to Fly” documentation	Doc	T0+32 months
D 6	Support to Flight Test Campaign	-	T0+30 months

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M 1	CDR	MS	T0+6 months
M 2	Fuel Test Rig Into Service	MS	T0+19 months
M 3	Fuel System Installation in the Aircraft completed	MS	T0+26 months
M 4	Flight test survey	MS	T0+30 months

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 Fuel System. 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 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.
With architecture validation, 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 the system engineering of complex Aircraft Fuel System architectures (M)
- Engineering Resources to provide Production Drawings, Test Reports and Documentation for Production and the substantiation for the Permit to Flight (M)
- Installation and Integration of Fuel Level Sensors (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). (A)
- Product Organization Approvals (POA). (Recommended) (see also comments below in § Certification)
- Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004)(M)
- Qualification as Material and Ground Testing Laboratory of reference aeronautical companies (i.e. ISO 17025 and Nadcap). (M)

- Mechanical processes, in both composite material and metallic. Hybrid joints (CFRP + Metal)
- 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) is recommended.
- Product Organization Approvals (POA): if POA is not granted to the partner, it could be acceptable if he can show experience on delivery of flyable systems or components and he has implemented a suitable quality system to monitor the manufacturing of flyable systems or components (including compliance with EN9100).
- 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).

Additional information:

The partner and the Topic Manager will have to agree and sign during the negotiation (before T0):

- An implementation Agreement as defined by Clean Sky 2.
- A Specific Agreement for the loan of material/equipment for integration tests on ground and in flight to cover aspects linked to the delivery by the partner of flying equipment's (obligation of the parties, insurance aspects for the partner), possibility to extend the loan after the end of Clean Sky 2.

X. Compound Rotorcraft Assembly tooling

Type of action (RIA or IA)	IA		
Programme Area	FRC		
Joint Technical Programme (JTP) Ref.	WP 2.13.2 (Flight demonstrator assembly)		
Indicative Funding Topic Value (in k€)	700		
Topic Leader	Airbus Helicopters	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	48	**Indicative Start Date**[37]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CFP06-FRC-02-26	**Compound Rotorcraft Assembly tooling**
Short description	
The aim of this topic is to develop and manufacture suitable tooling's to support the assembly and the operation of a fast compound rotorcraft and adapted to the specific architecture of this aircraft.	

[37] 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 Program, 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.
This innovative architecture leads to the need of new suitable methods and tools to insure the assembly and the operation of this demonstrator. Innovative solution will be welcome to insure in an efficient way the assembly of a rotorcraft design with a new architecture aircraft and built with components developed by several partners.

2. Scope of work

The subject of this Call for Partner is to include all activities needed for developing and manufacturing of tooling necessary to support the assembly and the operation of LifeRCraft demonstrator. For each item, the activity is including the definition of the tools according to the specification provided by the Topic Manager, the detail design and the manufacturing of the tools, the demonstration of the compliance to the requirements of the Topic Manager, the delivery of the tools at Topic manager premises and the support during the assembly and the test of LifeRCraft demonstrator.

The opportunities for innovation are:

- Unusual architecture of the aircraft (rotorcraft with a specific architecture)
- Optimized tooling for ergonomic aspects and personal safety
- Use of material with limited impact on environment

The tooling to support the assembly will include:

- Adjustable Jacks (used also for demonstrator tests)
- Wing installation tool
- Towing bar (used also for demonstrator tests)
- Cradle platforms for assembly
- Dummy landing gear

The tooling to support the demonstrator tests will include:

- Cradle platforms for maintenance

Adjustable Jacks: the purpose is to support the aircraft during the assembly or during maintenance operations (jacks electrically adjustable are suitable)

Type	Max Load (DaN)	Min. Height (mm)	Maximum Height (mm)	Number (including spare)
Front jack	7000	400	800	3
Rear jack	8000	800	1200	2
Nose Landing gear jack	4000	165	500	2
Main Landing gear jack	4000	165	500	2

Note: Load and height are order of magnitude, more accurate figure will be provided at T0.

- Temperature envelope: - 20°C to 45°C
- To be operated with:
    - industrial electrical network, one phase 50/60 Hz
    - + 28VDC
    - Internal Battery (loaded by AC network)

Each jack shall include retractable wheels (or equivalent) for moving on ground, a locking device in the selected height (until max load) and a manual device to insure the descent of aircraft without electrical supply (until max load).

Picture for example:

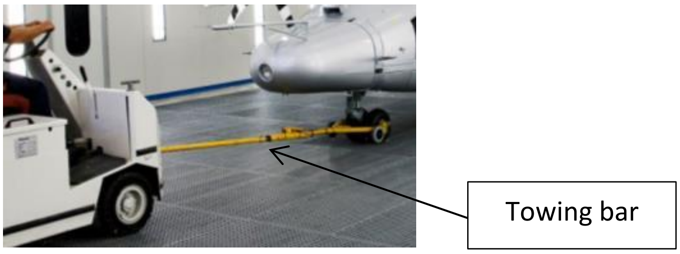
Towing bar:

The towing bar allow to pull the rotorcraft in a hangar or on the taxiway with a towing vehicle, the bar is connected to the front landing gear of rotorcraft (interface will be specified at T0). The bar shall be fitted with wheel for displacement on ground when pulled by the towing vehicle and not connected to the rotorcraft.

* Maximum load: +/-22.5 KN
* Safety device in case of overload 25 KN
* Length: 4 m

Note: Load and length are order of magnitude, more accurate figures will be provided at T0.

Picture for example:



Tool to support the installation of the wings on the fuselage:

This tool should be able to support each wing (LH and RH: symmetrical) during the assembly and able to induce the suitable preset by loading 2 interface points to insure a correct adjustment at the level of interface brackets:

* Height above the ground: 1500 mm
* Distance between each point: 500 mm
* Max load to be induced at each point: +/-300 DaN

This type of tool is specific to the architecture of this aircraft and the constraint of installation for wing which has to accommodate a drive shaft high level of tolerance required for a satisfactory operation.

Cradle platforms for assembly:

Set Platforms for the aircraft assembly: these platforms shall allow going around the aircraft during the assembly at the level of all systems or compartments which are not directly accessible from the ground as the engine and transmission deck, the tip wing nacelle, the wing, the upper part of the cabin, the empennage (horizontal and vertical stabilizers).

* Length of aircraft: 15 m
* Span of aircraft: 11 m
* The architecture of the aircraft will be similar to X3 demonstrator:

The system has to be adapted to the specific architecture of this aircraft.

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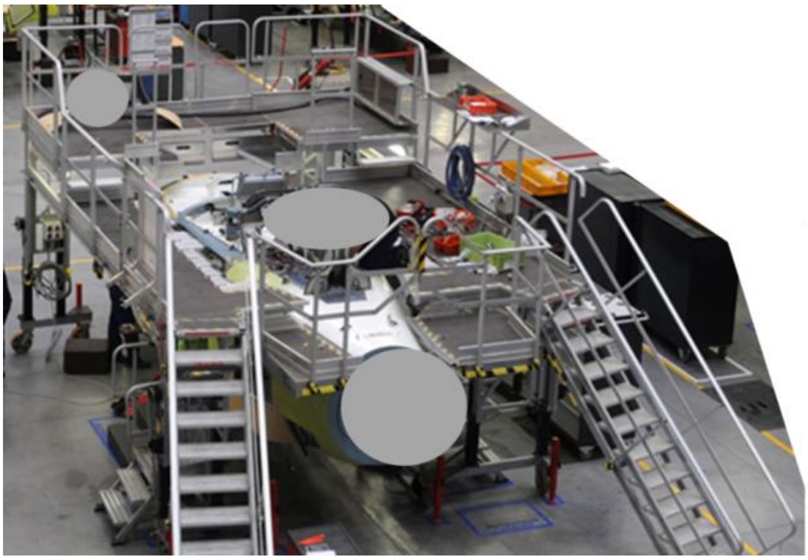
Example of cradle platform for assembly



© Airbus Helicopters

These platforms have to be modular.

Staircases have to be forecast to insure access on each side of aircraft or to each independent platform (front, tail, nacelle).

Type	Height of platform: (mm)	Length of platform (mm)	Width of platform (mm)	Max load (person number)	Comments
Front platform	1500	3000	1200	5	Access to the front fuselage at the level of the windshield
RH side platform	2500	4000	1500	5	On each side of fuselage, give the access to the upper part of fuselage in the front and the rear of the wing (allow to pass over the wing with a step on each side of the wing)
LH side platform	2500	4000	1500	5	
RH Nacelle platform	1000	1500	1500	4	Access to the lateral rotor and the lateral gearbox
LH Nacelle	1000	1500	1500	4	

Type	Height of platform: (mm)	Length of platform (mm)	Width of platform (mm)	Max load (person number)	Comments
platform					
Tail platform	1500	2700	2000	4	Access to horizontal and vertical stabilizer
Staircase for cockpit RH	900	N/A	1000	2	Access to cockpit floor
Staircase for cockpit RH	900	N/A	1000	2	
Staircase for cabin	900	N/A	1500	2	Access to cabin floor
Staircase to equipment bay	900	N/A	800	2	

Note: Load and dimensions are order of magnitude, more accurate figures will be provided at T0.

Each module can to be easily moved on the ground by 2 persons and can be locked in the suitable position. Each upper platform shall have a shape in accordance with the fuselage shape in order to have a limited gap between the platform (platform edge protected to avoid damage to fuselage). Other side of platform and staircase shall be fitted with handrail/ barrier.

Each platform shall include electrical plugs and air pressure plug connected to workshop networks (including safety device and shut-off system).

Example of staircase:

© Airbus Helicopters

Dummy landing gear:
The purpose is to build a set of tools replacing the aircraft landing gear in order to support the main airframe during the aircraft assembly and allow displacement of the aircraft within the workshop. It will include 3 modules:

- RH main landing gear (one wheel): max load: 4000 daN, height: 900 – 1300 mm
- LH Main landing gear (one wheel): max load: 4000 daN, height: 900 – 1300 mm
- Nose landing gear / swiveling (2 wheels): max load: 4000 daN, height: 700 – 1000 mm

Note: Load and dimensions are order of magnitude, more accurate figures will be provided at T0.

Each dummy landing gear will be connected to the airframe on the brackets supporting the normal landing gear components
The dummy landing gear is non-retractable
Wheels are fitted with inflatable tires
Each dummy landing gear has to be adjustable in height (see range above)
The Nose Landing gear has to able to be connected to the towing bar and to be able to support the towing loads.

Cradle platforms for maintenance
Platforms for the daily maintenance of the aircraft:

- 2 (symmetrical) for access to engine and transmission deck:
  - max load by platform: 3 persons
  - height of upper platform 2300 mm
  - Length x width: 2000 x 1000 mm
- 1 for access to the tail surfaces
  - max load by platform: 2 persons
  - height of upper platform 1500 mm
  - Length x width: 2000 x 1000 mm
- 1 for access to the main rotor
  - max load by platform: 2 persons
  - height of upper platform 2500 mm
  - Length x width: 2000 x 1000 mm
- 2 for access to the nacelles
  - max load by platform: 2 persons
  - height of upper platform: 1000 mm
  - Length x width: 1500 x 1000 mm

Each platform shall include steps (staircase) to reach the upper platform. The staircase and the upper platform have to be equipped of barrier / handrail to avoid falling of personal.
Each platform can to be easily moved on the ground by 2 persons without any other assistance and can be locked in the working position.

General requirements for all devices:
Compliance with standard CE-2006-42
Considerations of Safety and ergonomic aspects for the personal having to use the tooling is mandatory
Life duration: 4 years after delivery + potential extension of 3 additional years

The partner shall provide the support to the Topic manager during the all period of the assembly and the testing (until T0 + 48).

Important note: the picture provided in the description above are based on existing materials providing similar function and are given only to a better understanding of the requirement. It doesn't preclude the solution which has to be proposed and particularly innovative solutions in order to achieve the required functions are welcome.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D 1	Start activity		T0
D 2	Preliminary design	Report / Drawing	T0 +3 month
D 3	Substantiation documentation (including detailed characteristics)	Reports	T0+11month
D 4	Operation documentation	Document	T0+11 month
D 5	Delivery of tooling for assembly	HW	T0+14 month
D 6	Delivery of tooling for maintenance	HW	T0+20 month

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M 1	PDR	Review	T0+4 month
M2	CDR	Review	T0+8 month
M3	Acceptance of the substantiation documentation	Review	T0+13 month
M3	FAI	Review	T0+13 month

General remarks:

- 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. standards/methods/processes to be used).
- Final dimension will be defined during the negotiation phase with the partner
- A draft specification of each component will be provided by the topic manager during the negotiation with the partner.
- The final specification will be available at T0.

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

The Topic Manager is responsible to implement safety rules inside its premise in order to protect it personal or the personal having to work on the demonstrator (partner, supplier…), and it is therefore mandatory that the Topic Manager will be supported by the Partner with respect to all regulation a standard to be apply for the tooling equipment's of this topic. Therefore the Partner has to provide all documentation necessary to achieve this target:

- Providing material data which are required to achieve their compliance;

- Using material, processes, tools, calculation tools etc. which are commonly accepted in compliance with the required standard;
- 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 to establish compliance with required standards;
- Checking that the proposed design has a sufficient maturity in order to fulfill the required function with an acceptable level of reliability.

Weight:

The design shall be done to minimise the weight for the components to be moved by personal without the help of an external hoisting device: it include particularly cradle platforms and devices to be carry on board of demo.

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.

Special Skills

<u>Abbreviations</u>: (M) for Mandatory; (A) for Appreciated.

- Experience in design and manufacturing of tooling for aeronautical industry (A.)
- Design and analysis tools of the aeronautical industry (i.e. CATIA v5 r21, NASTRAN, VPM, Windchill) (A)
- Experience in management, coordination and development technological programs. (M)
- Proved experience in collaborating with reference aeronautical companies. (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 (M):
    - Personal safety substantiation
    - …
- Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004). (M)
- 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):
  - Dimensional and shaping inspections
  - Morphology studies of materials-if needed.
  - Welding inspection
- Into the eco design field, the Partner shall have the Capability to monitor and decrease the use of hazardous substances regarding REACH regulation (M).

Additional information:

The partner and the Topic Manager will have to agree and sign during the Grant Preparation Phase (before T0):

- An implementation Agreement as defined by Clean Sky2 …..
- A Specific Agreement for the loan of material/equipment (obligation of the parties, insurance aspects for the partner, possibility to continue the loan after Clean Sky 2 tests).

5. Abbreviations/Glossary:

CDR	Critical design Review
daN	Deca-Newton
FRC	Fast Rotorcraft
FTI	Flight Test Installation
PDR	Preliminary design review

XI. Rotor's Flight Test Instrumentation on demonstrator Fast Rotorcraft Project

Type of action (RIA or IA)	IA		
Programme Area	FRC		
Joint Technical Programme (JTP) Ref.	FRC 2.13.2 (Flight Test)		
Indicative Funding Topic Value (in k€)	1500		
Topic Leader	Airbus Helicopters	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	60	**Indicative Start Date**[38]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CFP06-FRC-02-27	**Rotor's Flight Test Instrumentation on demonstrator Fast Rotorcraft Project**
Short description	
The Demonstrator Fast Rotorcraft has to be fully instrumented with a Flight Test Instrumentation in order to acquire data on the systems on board. Focusing on dynamics system and due to the "novelty" of configuration of this rotorcraft with a Main Rotor, Lateral Rotors and Drive shaft, a large amount of data coming from rotating parts have to be acquired and transferred to central acquisition system.	

[38] 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, opens up to new mobility roles that neither conventional helicopters nor fixed wing aircraft can currently cover in a sustainable way.
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.
In order to set up and validate all these news technologies and breakthrough the FRC demonstrator will be fully instrumented with an "unusual" Flight Test Instrumentation made of various sensors and digital acquisition units. Particularly specific vehicle systems (Rotor, wings vs drive shaft and lateral rotors) need a particular data acquisition device.

2. Scope of work

The subject of this Call for Partner is to include all activities needed for developing and manufacturing the dedicated Flight Test equipment for:

- **a)** Main Rotor (MR)
- **b)** Lateral Rotors (LR)
- **c)** Drive shaft systems

The scope of the task includes the electronic device development, manufacturing and delivery (included spare part) for acquisition system to be installed on rotating axis as well as the "link" between rotating and fixed part.
More, for drive shaft and lateral rotors, the scope includes the installation and wiring of the sensors (for stress, temperature, vibration…) and also the calibration of the complete system in order to allow Topic Manager Team to perform relevant data processing and analysis.

Compliance of all systems with current standard is also mandatory (incl. ETHERNET bus line format, system configuration format, data reduction SW suites but also incl. of specific Topic Manager FTI devices).

General consideration about architecture:

- For the 3 item the systems must be fully configured by software: parameter's type, gain, Range, sample rate, Bandwidth, filtering, shunt calibration, output configuration stream…..

- For Main & Lateral Rotor, the hardware configuration should be the same family and the system must be modular in order to avoid the complete change of the system in case of 1 channel failure: module of 8 / 12 channels could be considered.

The system could be settable from 8/12 to 72 channels.

- System Power supply on rotating part:

For Lateral Rotor and drive shaft system a wireless data transmission will be mandatory and battery power must be avoided.
For Main Rotor wireless and/or contacts/wires data transmission and power could be consider

Finally, concerning the design constraints, the complete certification of the system developed is not required but the mechanical design / substantiation must be fully compliant with the CS29 and concerning environmental conditions: vibrations, shocks, temperatures, and humidity, EMI/EMC, the D160 G recommendation must be fully respected and reached.

The overall scope may be split in 3 separate “modules” (Main Rotor, Lateral Rotor, Drive Shaft) if more adapted regarding the different technologies to be developed.

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

2.1 MAIN ROTOR acquisition system:

The subject is to develop and provide 2 acquistions means (1+1 spare) able to be installed on main rotor head.
The means to be installed (included acquisition and Rotor/stator link) are to be integrated under the rotor head fairing envelope (assuming minimization of weight and volume).
The system will be connected by wires to the sensors installed by Topic Manager on several Main Rotor components (ie: strain gages, temperatures probes , accelerometers, potentiometers….)

General remarks:

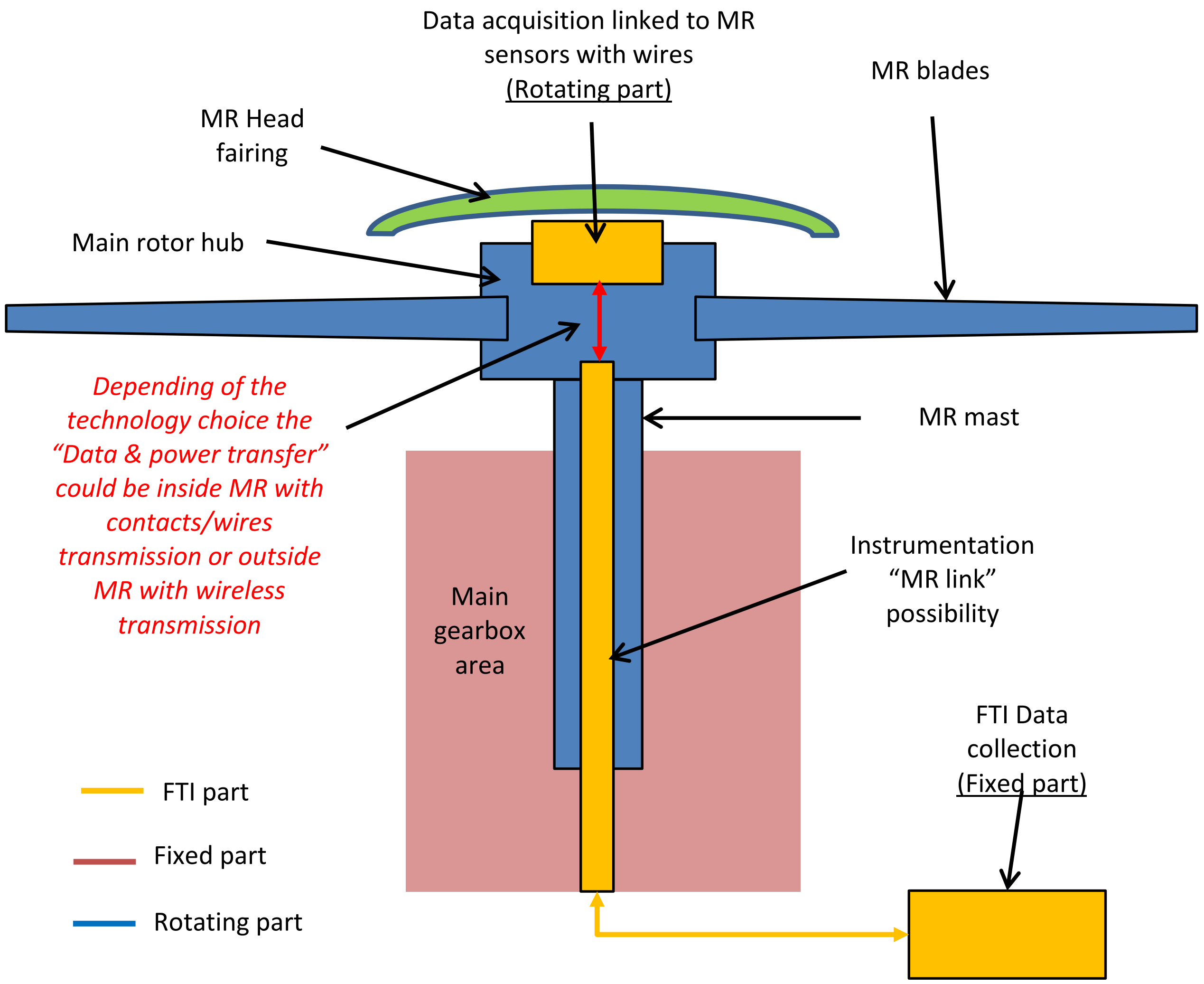
The substantiation documentation has to be done according the requirements of the Topic Manager. An harmonization process of the terms of conditions will take place at start of the project (e.g. tools/methods/processes to be used).

The main specification are:

Specifications: preliminary information's to give order of magnitude	
Item	***capacity***
Nbers of system to be deliver	2 (1 + 1 Spare)
Nbers of channels	64 channels
Parameters type	Full/half/quarter bridges(120 to 1000 Ohms), PT100 temperature, thermocouple K, IEPE accelerometers, potentiometers
Main Rotor rotational speed	0 to 1000 rpm
Input Range programmable	+/-5mv up to 10v
Zero offset adjustable	TBD (50% FS)
Bandwidth adjustable by channel	Up to 12Khz
Max sample rate /Ch. (Hz)	>50Khz
adjustable excitation / Ch.	Current (up to 15mA) and/or voltage (up to 5V) TYP
Filtering feature	Analog filter : yes High pass filter: yes Anti-aliasing filter : yes Digital filter: IIR and/or FIR adjustable Filter delay: fix delay & identified } Filtering detail to be fixed during negotiation
Temperature feature	Ambient temperature usage : -50 to +100°C All Measurement temperature compensation: -40 to +85°C
Accuracy/Ch. (all included with temperature drift)	Less than 0,3% FSR
Remote Shunt calibration/Ch.	Programmable/Ch.
Rotor /stator transmission	Contact or wireless link : TBD
Power supply	DC power 10 to 32 V, In case of wireless: power by battery must be avoided (mandatory)
Data bus delivery format	Output of the system must be in ETH IENA format (compatibility with AIRBUS)
Data time stamping	All data must be synchronized and time tagged following PtP time protocol (IEEE 1588) V1 & V2
System configuration	The system must be fully configured by computer: channel type, full scale, gain, sampling rate, filtering…. The configuration file must fully compatible with AIRBUS system management tools "FTI Manager" (XIDML , XIDefML file)
Altitude pressure usage	Up to 25000 ft
Mechanical integration	To be compliant with rotor head design without any fairing modification: Diameter 150mm, height :100mm, max weight: 3KG
Mechanical design & Substantiation	According with CS29 regulation to be validated by AIRBUS design office
Environmental constraint	Complaint with due Rotorcraft chapter DO160 G for temperature, vibration, humidity, shock, EMI/EMC (detailed requirements according vibration frequencies and location of components will be part of the specification to be provided at T0).

Sketches of requirement

It is preliminary information's to give order of magnitude; final data will be defined during negotiation before T0.



- *External dimensions (space allocation for integration):*

Data collection (rotating part): diameter: 150mm, height: 100mm weight 3Kg
Instrumentation "MR Link ": Diameter: 80mm, length: 1700mm

2.2 Lateral rotor acquisition system:

The subject is to develop and provide 3 acquistions means able to be installed on each Lateral Rotor (1 / Lateral Rotor + 1 spare).

The means to be installed on lateral rotor (included acquisition and Rotor/stator link) are to be installed under the hub faring envelope (assuming minimization of weight and volume).

The “selected partner”will provide and install, in his own facilities, the acquisition means as well the sensors and the associate wiring needed on part (ie: Full/quarter bridge, temperatures probes, accelerometers ….)

Caution: to be taken into account the possibility to perform the job at Topic Manager premises if needed to protect industrial property or to ease delivery time scale.

General remarks:

- The substantiation documentation has 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/processes to be used).

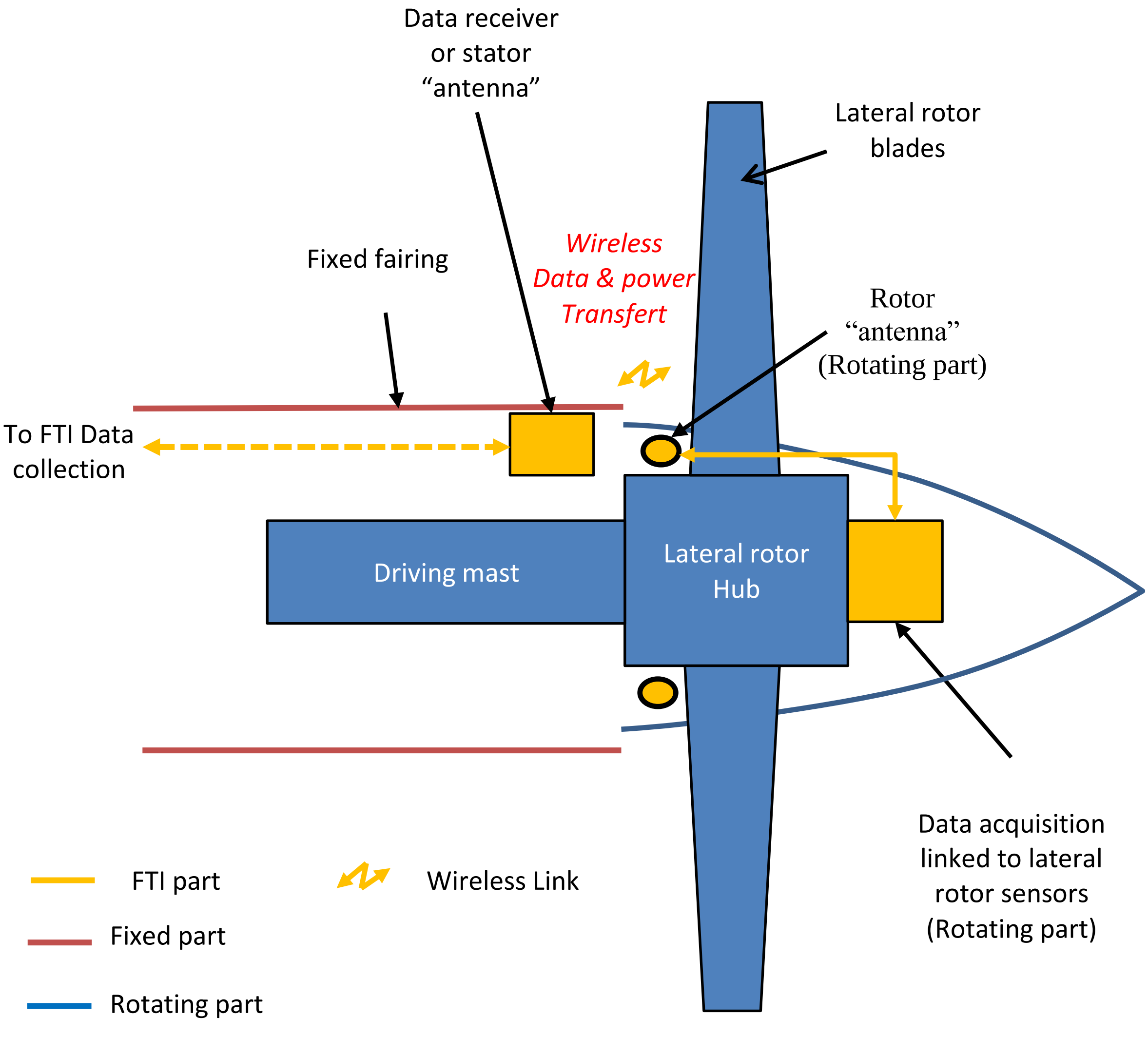
The main specifications are:

Specifications: preliminary information's to give order of magnitude	
Item	***capacity***
Nbers of system to be deliver	3 (1/lateral Rotors=2 and 1 spare)
Nber of channels	32 channels
Parameters type	Full/half/quarter bridges (120 to 1000 Ohms), PT100 temperature, thermocouple K, IEPE accelerometers, potentiometers
Lateral rotor rotational speed	0 to 2000 rpm
Bandwidth adjustable by channel	Up to 12Khz
Max sample rate /Ch. (Hz)	>50Khz
Input Range programmable	+/-5mV up to 10V
Zero offset setup	TBD (50% FS)
Programmable excitation /Ch	Current (up to 15mA) and or voltage (up to 5V)
Filtering feature	Analog filter : yes High pass filter: yes Anti-aliasing filter : yes Digital filter: IIR and/or FIR adjustable Filter delay: fix delay & identified } Filtering detail to be fixed during negotiation
Temperature feature	Ambient temperature usage : -50 to +100°C All Measurement temperature compensation: -40 to +85°C
Accuracy/ch (all included with temperature drift)	Less than 0,3% FS
Remot Shunt calibration/CH	Programmable /ch
Rotor /stator transmission	wireless link
Power supply	DC power 10 to 32 V, In case of wireless: battery must be avoided (mandatory)
Data bus delivery format	Output of the system must be in ETH IENA format
Data time stamping	All data must be synchronized and time tagged following PtP time protocol (IEEE 1588) V1 & V2
System configuration	The system must be fully configured by computer: channel type, full scale, gain, sampling rate, filtering…. The configuration file must fully compatible with AIRBUS system management tools "FTI Manager" (XIDML file)
Altitude pressure usage	up to 25000 ft
Mechanical integration	To be compliant with rotor head design without any fairing modification : Diameter 150mm, height :100mm, max weight: 3KG
Mechanical Substantiation	According with CS29 regulation to be validated by AIRBUS design office
Environmental constrain	Complaint with due Rotorcraft chapter DO160 G for temperature, vibration, humidity, shock, EMI/EMC (detailed requirements according vibration frequencies and location of components will be part of the specification to be provided at T0).

Sketches of requirement

Volume available under the lateral rotor head fairing to install the system (excepted wirings) and for the "link" between rotating and fixed part:

It is preliminary information's to give order of magnitude; final data will be defined during negotiation before T0.



- External dimensions (space allocation for integration):

Data collection (rotating part): diameter: 150mm, height: 100mm, Max weight: 3KG
Data receiver/Stator (fixed part): 100x100x50mm, weight: to be discuss

2.3 Drive shafts system:

The subject is to develop and provide acquistion means able to be installed on drive shafts system i.e power line from MGB power in to Lateral Rotor drive shaft system.

For each shaft, two lines of power have to be instrumented (left and right side)

Three different shafts are to be managed:

1. MGB power IN flange coupling (input stage of MGB)
2. Lateral Rotors torque measurment
3. Lateral Rotors shaft flange coupling

The means to be installed on each shaft (included acquisition and Rotor/stator link) must be fixed on shaft taking into account the rotation speed of each one.

Volume available around each shaft is very limited.

As an example the electronic device to be embedded should be a "flex substrats" in order to be adapted to the shape of the shaft within the following size envelope:

- Thickness: 3 mm
- Width: 10.5 mm
- Length along the shaft: 55 mm
- Weight: 5 grams

A particular care has to be taken ino account regarding weight and balance of the equipement to be installed on the shaft in order to ease the final balancing phase.

The "selected partner"will provide and install in his own facilities (also taken into account at Topic Manager premises if needed to protect industrial property or to ease delivery time scale) for each shaft the acquisition means as well the sensors and the associate wiring needed on each shaft (ie: Full/quarter bridge, temperatures probes ….) - assuming minimization of weight and volume.

General remarks:

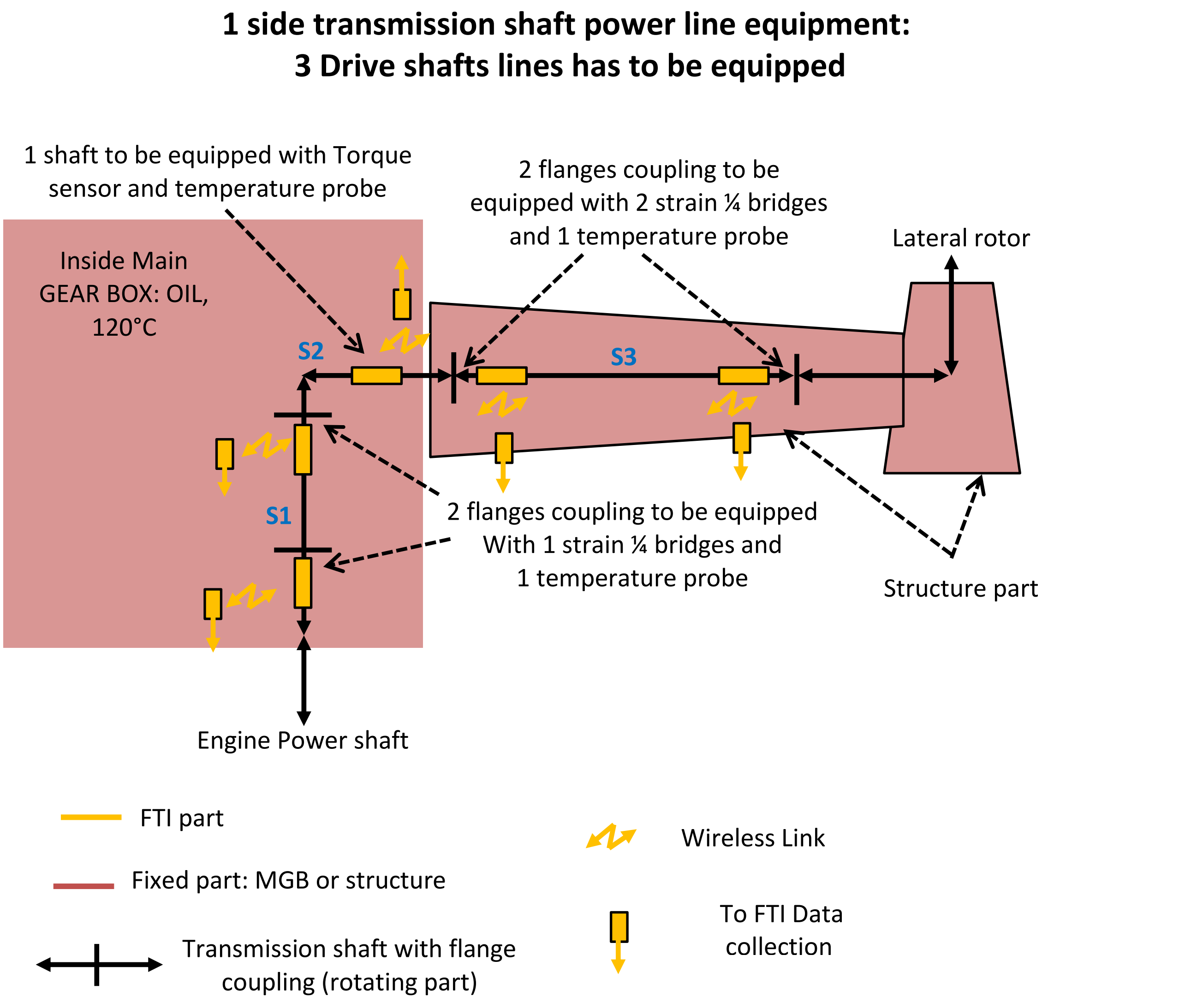
- The substantiation documentations have to be done according the requirements of the Topic Manager. A harmonization process of the terms of conditions will take place at start of the project (e.g. tools/methods/processes to be used).

The main specification are:

Specifications: preliminary information's to give order of magnitude	
Item	***capacity***
Nber of channels	up to 6 channels by drive shaft (depending of the shaft)
Nber of drive shaft to be deliver	9 Drive shaft (3 type of shaft *2 line shaft R/L + 1 spare of each type)
Parameters type	Full/half/quarter bridges(120 to 1000 Ohms), PT100 temperature
Shaft rotational speed	**S1:** MGB power IN flange coupling 0 to 9000 rpm **S2:** Lateral Rotors torque measurment 0 to 4000 rpm **S3:** Lateral rotors shaft flange coupling 0 to 4000 rpm
Bandwidth by channel	Up to 2Khz
Input Range programmable	+/-0,2mv up to 40mv
Output range if analogue	+/-10V
Zero offset setup	TBD (50% FS)
Anti-aliasing	yes
Filter fix delay	yes
Temperature feature	Ambient temperature usage : -50 to +130°C All Measurement temperature compensation: -40 to +120°C
Accuracy (all included with temperature drift)	Less than 0.5% FS
Remote Shunt calibration/CH	Programmable /ch
Rotor /stator transmission	wireless
Power supply	wireless link and power by battery must be absolutely avoided (mandatory)
Data bus delivery format	Output of the system could be in ETH IENA format but high level analog output could be consider to be acquire by Topic Manager means
Data time stamping	In case of ETH IENA out, All data must be synchronized and time tagged following PtP time protocol (IEEE 1588) V1 & V2
System configuration	The system must be fully configured by computer: channel type, full scale, gain, sampling rate…. For ETH IENA out, the configuration file must be fully compatible with AIRBUS system management tools "FTI Manager" (XIDML, XIDefML file)
Ambient Temperature usage	For all instrumented shaft -40 to +120°C (target -55 to 130°C)
Altitude pressure usage	up to 25000 ft.
Mechanical integration	To be compliant with high rotation speed of the different shaft and also the necessary balancing criteria to be reach
Environmental constrain	According with CS29 regulation to be validated by AIRBUS design office
Environmental constrain	Compliant with due Rotorcraft chapter DO160 G for temperature, vibration, humidity, shock, EMI/EMC (detailed requirements according vibration frequency and location of components will be part of the specification to be provided at T0).

Sketches of requirement

It is preliminary information's to give order of magnitude; final data will be defined during negotiation before T0.



3. Major deliverables/ Milestones and schedule (estimate)

3.1 MAIN ROTOR acquisition system

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D 1	Start activity		T0
D 2	Architecture design freeze	Report / Drawing	T0 +2 month
D 3	Proof Of Concept (POC) demonstration		T0+4 month
D 4	Delivery of a first protoptype for Lab test validation in Topic Manager facilities	HW	T0+9 month
D 5	Delivery of first equipment for Test Flight on existing conventional helicopter	HW	T0+12 month
D 6	Delivery of final equipement included spare Part	Support	T0+18 month

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M1	CDR	Review	T0+6 month
M2	Lab test validation in Topic manager facilities	Support	T0+10 month
M3	Test Flight on existing conventional helicopter	Support	T0+13 month
M4	FAI	Review	T0+18 month
M5	Ground and Flight test survey: system in operation on FRC demonstrator	Support	T0+27 month

3.2 LATERAL ROTOR acquisition system:

Deliverables			
Ref. No.	***Action to be done***	***Type***	***Due date***
D 1	Start activity		T0
D 2	Architecture design freeze	Report /drawing	T0 +2 month
D 3	POC demonstration		T0+4 month
D 4	Delivery of a first prototype for Lab test validation in Topic Manager facilities	HW	T0+9 month
D 5	Operational test during ground run: to be define		T0+12 month
D 6	Delivery of final equipement included spare Part	HW	T0+ 18 month

Milestones			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M 1	CDR	Review	T0+6 month
M 2	Lab Test validation in Topic Manager facilities	Support	T0+10 month
M 3	FAI	Review	T0+18 month
M 4	Ground and Flight test survey: system in operation on FRC demonstrator	Support	T0+30 month

3.3 Drive shafts system:

Deliverables			
Ref. No.	***Action to be done***	***Type***	***Due date***
D 1	Start activity		T0
D 2	Architecture design freeze	Report /drawings	T0 +2 month
D 3	POC demonstration		T0+4 month
D 4	Delivery of first prototype for Lab test validation in Topic Manager facilities	HW	T0+9 month
D 5	Operational test during ground run: to be define		T0+12 month
D 6	Delivery of final equipement included spare Part	HW	T0+18 month

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M 1	CDR	Review	T0+6 month
M 2	Lab test validation in Topic Manager facilities	Support	T0+10 month
M 3	FAI	Review	T0+18 month
M 4	Flight test survey	Support	T0+30 month

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 flight clearance related activities in relation with the instrumentation.
Therefore the Partner has to provide all documentation necessary to achieve "Permit to Fly" and has to perform all actions to reach this target:

- 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 for a flight on a test aircraft;
- Facilitating harmonization of calculation processes/tools with the Topic Manager;
- Acting interactively 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 insufficient documentation for authorities;
- Checking TRL level 4 is reached for each system/technology upon project start (Q4 2017). Should this condition not be met, the Partner has to provide a mitigation plan enabling to reach the target of flyable equipment for the first flight of the demo.

Weight:

Even if the system is not installed on a serial aircraft, the design has to be done in the way to minimise the weight in order to limit the impact on the demonstrator weight and to limit the impact on behaviour of rotating parts.
The applicant(s) shall provide an estimated maximum weight of its proposed component. This value will be updated until CDR.
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.

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 compatible with CATIA V5 R21. The data necessary for configuration management have to be provided in a format compatible with VPM and Windchill tool.

Special Skills

<u>Abbreviations</u>: (M) for Mandatory; (A) for Appreciated.

- Competency 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. (A)
- Proven experience in collaboration with reference aeronautical companies (M)
- Proven experience in development of flyable aeronautical equipment's (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). (A). If not, it shall demonstrate the capability to provide substantiations in term of stress and environmental requirements as required above (M)
- Capacity to specify equipment tests (stress, environment as required above) 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 (A)
- Capacity to repair "in-shop" components due to manufacturing deviations. (M)
- Design Organization Approval (DOA). (A)
- Product Organization Approvals (POA). (A)
- Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004)(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 the Topic Manager.
The TRL review must be held within the CDR and must confirm a maturity of TRL5 or at least TRL4 if a solid action plans to reach TRL5 when the flying equipment's will be delivered 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 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 demonstrator.

5. Additional information:

The partner and the Topic Manager will have to agree and sign during the negotiation (before T0):

- An Implementation Agreement as defined by Clean Sky2.
- A Specific Agreement for the loan of material/equipment for integration tests on ground and in flight to cover aspects linked to the delivery by the partner of flying equipment's (obligation of the parties, insurance aspects for the partner), possibility to extend the loan after the end of Clean Sky 2.

6. Abbreviations/Glossary:

CDR	Critical design Review
Ch.	Channel
CS29	Certification Specifications for Large Rotorcraft issued by European Aviation Safety Agency (EASA)
DO160G	Environmental Conditions and test Procedures for Airborne Equipment
EMI	Electromagnetic Interference
EMC	Electromagnetic Compatibility
ETH	ETHERNET BUS
FRC	Fast Rotorcraft
FTI	Flight Test Installation
IENA	ETHERNET Protocol compatible with AIRBUS FTI means
MGB	Main Gear Box
MR	Main Rotor
POC:	Prove of Concept
PtP (V1&V2):	Precise Time Protocol (version 1 & 2)

4. Clean Sky 2 – Airframe ITD

I. Prediction of aerodynamic loads at high Reynolds Number

Type of action (RIA or IA)	RIA		
Programme Area	AIRFRAME		
Joint Technical Programme (JTP V5) Ref.	WP A-1.4.5		
Indicative Funding Topic Value (in k€)	1900		
Topic Leader	Dassault Aviation	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	30	**Indicative Start Date**[39]	Q1 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CfP06-AIR-01-25	**Prediction of aerodynamic loads at high Reynolds Number**
Short description	
The aim of this project is the improvement of the loads and efficiency prediction of control surfaces at High Mach and flight Reynolds numbers. The partner will have to design and manufacture model parts to be tested in a wind tunnel in flight conditions (speed and Reynolds number). In particular a new concept of hinge moment balance and modification of an existing model provided by the Topic Manager will be designed and modified regarding the tests requirements. For crosscheck purpose, the partner will have to propose two different measurements techniques for hinge moment.	

[39] The start date corresponds to actual start date with all legal documents in place.

1. Background

Under Airframe ITD, Workpackage A-1.4 focuses on the enhancement of virtual modelization in the design processes for certification purpose. The necessary software developments as well as tests will be specified and carried out for several applications:

1. Improvement of aircraft noise modelling using certification data
2. Advance criteria for rapid dynamic / Crash modelling for safety
3. Safety of composite fuel tank - Lightning
4. Model based integrated systems analyses
5. Prediction of aerodynamic loads at high Reynolds number
6. Cabin thermal modelling - Human model

Task #5 of this WP A-1.4 is dedicated to the improvement of the loads and efficiency prediction of control surfaces at High Mach and flight Reynolds Number. To reach this goal, measurement tools have to be improved. For the needs of this project, they have to be designed and developed to measure the appropriate information during wind tunnel tests. The outcome will provide results and knoweldge in order to compare through another project the wind tunnel results with flight tests and computations results. This will help defining a better process for the next aircraft generation to predict the loads and hinge moment in transonic conditions before flight tests, and thus, defining the right structure for the airplane, without weight excess.

2. Scope of work

The objective of the work to be performed by the Partner consists in the design, manufacturing and testing of a new mock-up technique to predict the loads and hinge moment of control surfaces.
The activities requested to the Partner should be organised through a WBS defined as follows:

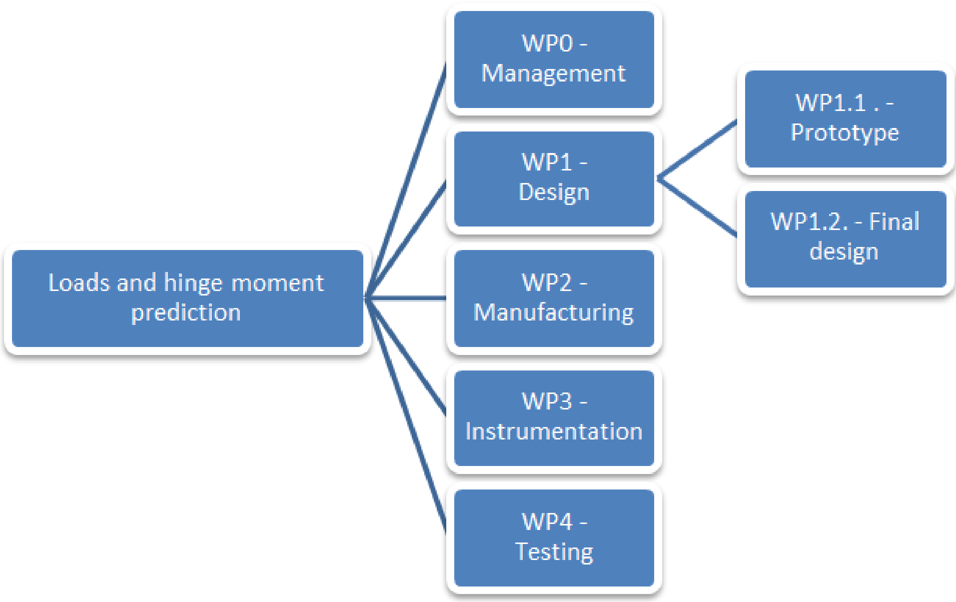


Figure 1: Work Breakdown Structure

Management – WP0

This work package will provide a proper management of the project in order to ensure that all the obligations of the Applicant are totally fulfilled, from a contractual, financial and technical point of view. The Applicant shall organise the work in all the WPs and report to the Topic Manager all along the project.

Design - WP1

The Applicant has to design entirely the model parts which will be tested, including the instrumentation tools. The Topic Manager will provide an existing 1/16 scale model of a business jet.
The CAD files generated in this project must be sufficient for parts manufacturing.
The activities are divided into two steps:

- First, to build a prototype of a hinge moment balance to be tested in a laboratory wind tunnel to prepare the design of final model and its instrumentation.
- Secondly, final design of the model which will be modified for industrial tests, including hinge moment balance on ailerons as well as pressure integration.

Prototype phase - WP1.1

The Applicant shall design a prototype of a hinge moment balance to be tested in a laboratory wind tunnel to be sure that the concept is validated for the industrial wind tunnel tests. The Topic Manager will support this activity if needed.

Final design phase - WP1.2

The Applicant shall lead this final design phase and perform the complete detailed design to deliver the entire CAD files and drawings to ensure parts manufacturing. This final phase will take into account the conclusions of the prototype design phase, the instrumentation requirements provided by the Topic Manager and the existing and targeted model definition.

Manufacturing – WP2

The objectives of WP2 is to provide the model parts for the tests. To be representative of the others results available for comparison, the model modifications shall include:

- New fuselage spacer (+ karman) to allow front fuselage translation
- New aft fuselage to allow straight sting integration
- New fin
- New HTP
- News pylons and nacelles
- Wings modifications or new Wings
- New winglets
- A straight sting

Instrumentation – WP3

The Applicant shall define within WP3 the best way to equip the model with pressure taps, strain gauges and others instrumentations to perform tests. The Applicant must prove by preliminary tests of specimens that the technical solutions for the instrumentation is compatible with the tests requirements.
The Applicant shall equip the model with the all the instrumentation compatible with the wind tunnel

requirements.

Testing – WP4

The Applicant shall perform first laboratory tests to prove that the new concept of hinge moment balance is viable. All the measurements tasks and analyses of the tests will be performed in this WP to deliver its conclusions to WP1.2.

In the second phase of testing, the Applicant will perform industrial tests and will measure all the information needed to be compared to computation and flight tests results. This comparison will be performed by the Topic Manager in order to define a new process of certification.

The Topic Manager is keen to have both types of measurement such as pressure integration (through pressure sensitive paint) and strain gauges for crosscheck goals.

These tests will be representative of flight conditions in term of Reynolds number for transonic Mach number up to 0.97. The control surface to be studied will be an aileron with up to seven different settings ranging from -30° to +30°. However, load measurement on winglet has to be performed.

Pure Aero elastic, Reynolds number effect on the load measurement shall be assessed during the tests.

Crosschecking of theoretical structural model has to be performed through static load tests with deformation measurement at wind tunnel test temperature.

List of the tasks

In summary, the following tasks have to be performed by the Applicant:

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T0	MANAGEMENT OF THE PROJECT	T0+30
T.1	DESIGN PHASE	
T.1.1.1.	Design of a hinge moment balance prototype	T0+9
T1.2.1.	Design of the complete model after modifications	T0+16
T2	MANUFACTURING	
T2.1.	Delivery of the balance prototype	T0+12
T2.2.	Delivery of the modified model parts	T0+21
T3	INSTRUMENTATION	
T3.1.	Equipment of the balance prototype	T0+13
T3.2.	Equipment of the complete model	T0+22
T4	TESTING	
T4.1.	Laboratory tests to validate the concept of the hinge moment balance	T0+15
T4.2.	Industrial tests in flight conditions, including static loading test ahead of the wind tunnel test	T0+28
T4.3	Analyses of the measurements	T0+30
T4.4	Delivery of the wind tunnel tests results	T0+30

Applicant Mission and IPR's

If necessary, the Topic Manager will support the Applicant in the design phase. The Applicant will work in close cooperation with the Topic Manager who will provide the adequate information. 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 CS JU.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1.1	Design of the balance prototype	Document + CAD files	CDR1
D1.2	Design of the complete model	Document + CAD files	CDR2
D2.1	Delivery of the model parts	hardware	Model buy-off
D3.1	Instrumentation of the model and its calibration	Hardware + document	Model buy-off
D4.1	Tests report	Document	Final Meeting
D4.2	Analyses and Data of the wind tunnel tests	Document + data	Final Meeting

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Prototype Critical Design Review (CDR1)	Meeting	T0+9
M2	Preliminary Design Review (PDR)	Meeting	T0+14
M3	Critical Design Review (CDR2)	Meeting	T0+16
M4	Model buy-off	Meeting	T0+26
M5	Final Meeting	Meeting	T0+30

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

- The Applicant shall have a large experience in designing and manufacturing model parts for aerodynamic wind tunnel tests in cryogenic condition.
- The Applicant shall have a large experience in testing at flight Reynolds conditions.
- The Applicant shall be proficient in using Dassault Systèmes CATIA V5 r20 software (Design modules in particular).

II. Development of innovative and optimized stiffeners run-out for overall panel weight saving of composite wing

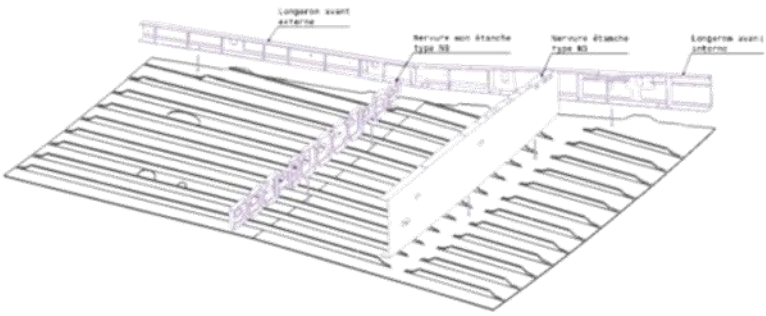
Type of action (RIA or IA)	RIA		
Programme Area [SPD]	AIR		
(CS2 JTP 2015) WP Ref.	WP A-3.1		
Indicative Funding Topic Value (in k€)	750		
Topic Leader	Dassault Aviation	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	32	**Indicative Start Date**[40]	Q1 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CfP06-AIR-01-26	**Development of innovative and optimized stiffeners run-out for overall panel weight saving of composite wing**
Short description	
The objective here is to develop the tools and the methodology to optimize the design of a stiffener run-out on a composite stiffened panel (stiffener geometry, thicknesses and lay-ups of different components, shape of the tapering). Based on mechanical test of typical configurations, both simulations and failure criteria will be developed for strength predictions capability. This development shall lead to a simple methodology dedicated to support the design of innovative and improved panel configurations taking into account the plain area as well as the stiffener run-out. The validation of optimized solutions will be supported by mechanical tests.	

[40] The start date corresponds to actual start date with all legal documents in place.

1. Background

On blade stiffened composite panels, the stiffeners run-out is a critical area due to the complex behaviour and to the vulnerablity to local stress concentration which can intiate the failure of the panel. Reinforcements are required to transfer the loads from the stiffener to the skin, this having a significant impact on the panel weight.



Typical composite wingbox panel

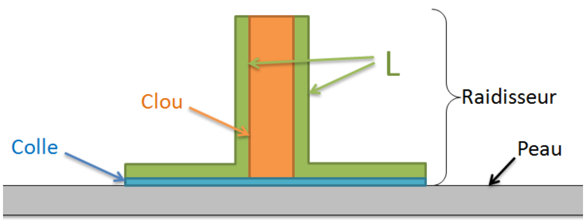
Today, the stiffener is generally designed while considering the plain area of the panel, then empirical solutions are tested for the run-out local reinforcements. The strength of simple tapering geometries is evaluated. The skin thickness then needs to be locally increased to reduce the overall stress in the area to adjust to the strength of the run-out.
This leads to under optimized solutions, not only at the local level but also at the global panel level (a stiffener configuration could be optimal for the current area while generating a strong weight penalty at the run-out).
The idea here is not only to look for innovative shapes of run-out and/or optimized additional fittings but also investigate possible compromises between generic geometry and run-out, leading to a global panel optimization. Therefore, the objective of the activity is to provide better tools for the design of stiffener run-outs and composite panel in general by developping a simple methodology to predict the failure of any stiffener run-out configuration, and thus allowing simple trade-offs for a better optimization of the panel.
A framework for initial composite panel configurations will be provided by the topic manager as a starting reference point (materials, general panel geometry with supporting substructure, typical loads, existing stiffener configurations and currently applied run-out geometries).

2. Scope of work

The applicant is asked to develop a methodology and failure criteria to predict in a simple way the strength of stiffener run-outs for composite panels. The relevance of the methodology shall be demonstrated with the search for innovative design of stiffener run-outs, looking at stiffener and skin local architecture, geometries, fitting designs for load transfer. In addition, more global optimization trends between current area and local reinforcements will need to be addressed. The methodology and the validation of the optimized architectures will be supported through a number of mechanical tests.
The proposed Work breakdown structure is as follows:

Tasks		
Ref. No.	***Title - Description***	***Due Date***
WP1	Experimental study of stiffener run-out	T0+12
WP2	Development of failure criteria	T0+18
WP3	Design of innovative stiffener run-out	T0+24
WP4	Validation phase	T0+32

WP1 – Experimental study of stiffener run-out behaviour
The purpose of WP1 is to establish an experimental base of stiffener run-out behaviour and failure which will be used to develop a modelisation and to generate the failure criteria in WP2.
The framework and constraints for the activity will be defined by the Topic Manager at the beginning of the project, such as:
- panel configuration boundaries with respect to thicknesses, lay-ups, geometries and architectures of stiffeners. It is already settled that the study will deal with T stiffened panels and the stiffeners will be co-bonded with the skin. The stiffener will be composed of 2 L's with symetrical lay-up and a center part for the web. The different locations of stiffener run-out (at a rib, at the root of the panel or along a spar on the side of the panel) and the corresponding load configurations will be provided by the Topic Manager.
- materials and and manufacturing process for the panel. In particular M21EV/IMA prepreg tape from Hexcel will be used for the skin and stiffeners. The skin will be precured and the stiffeners will be cobonded with FM300 adhesive.
- loading conditions, damage tolerance and environmental conditions. In particular damage tolerance has to be taken into account, the impact energy levels will be provided by the Topic Manager.
- a few configurations of reference for the stiffener run-outs (5 to 6 taking into account design for tension and for compression) with a complete definition of skin thickness,lay-ups and stiffener architecture. This will serve as the baseline for the work to be performed.
A typical section of stiffener is presented hereafter:



The applicant shall:
- define a test matrix and test procedure based on the reference configurations described hereabove including a definition of the loading set-up and of the stiffener run-out test component (see example below);
- manufacture the panels necessary to extract the test components as defined in the test programme;
- prepare the test components and the test set-up;
- perform the tests (necessary instrumentation shall be defined).
Some tests will have to be performed in hot-wet condition with impact damage in the stiffener run-out area

to determine their influence on the failure behaviour. Environmental conditions could be limited to temperature for part of the tests due to time constraints. The influence of anti-peeling fasteners location at the run-out should also be evaluated.

Example of test component in compression

Example of test component in tension

WP2 – Development of failure criteria

The objective of this WP is to come up with a simple methodology to predict the failure load of a stiffener run-out area. The different components tested in WP1 will be modelized with the required representativity according to the simulation strategy. The simulation supported by the test results will be used to develop a methodology to predict the failure criteria of the stiffener run-out. The criteria must take into account damage tolerance and environmental aspects.

The methodology developed must be simple enough to be used in a design phase to evaluate several stiffener configurations. Innovative and optimized solutions will be required. Therefore, the failure criteria are expected to be generated through the exploitation of simple FE models and/or parametric curves.

WP3 – Design of innovative stiffener run-outs

Using the reference panels as a starting point, a design phase for improved overall weight will be carried out. The methodology developed in WP2 will be used to develop and enhance innovative and improved solutions for stiffener and stiffener run-out.

In particular the following parameters shall be explored:
- lay-up and thickness of the different components of the stiffener;
- ply build up of the skin at the stiffener run-out;
- geometry of the stiffener cut-out, stiffener flange width, interest for anti-peeling fasteners;
- interest of additional metallic fittings to re-inforce the stiffener.

The presentation of an improved solution is required for at least two configurations in tension and two configurations in compression which will be selected with the Topic Manager.

This WP will be carried out in strong cooperation with the Topic Manager who will provide support regarding multi-disciplinary constraints of a wing panel, failure criteria and sizing methodologies. The improved designs will be joint results to be shared with the Topic Manager.

WP4 – Validation

The design solutions generated in WP3 will be manufactured and tested, taking into account the environmental and damage tolerances constraints. The experimental procedure is expected to be similar to the one developed in WP1. However, testing of multi-stiffened panels or closed box is also expected, in particular to validate the configuration of stiffener run-out close to a spar.

This will validate the expected performances of the improved solutions and the overall methodology

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1.1	Test definition programme		T0+3
D1.2	Test analysis report		T0+12
D2.1	Methodology for run-out failure prediction report		T0+18
D3.1	Innovative stiffener run-out design		T0+24
D4.1	New design testing and analysis reports		T0+32

*Types: R=Report, D-, HW=Hardware

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1.1	Experimental base established		T0+12
M2.1	Readiness of methodology for failure prediction		T0+18
M3.1	Innovative design review		T0+24
M4.1	Validation of innovative design		T0+32

*Types: R=Report, D-Data, HW=Hardware

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

- Experience and capability to manufacture composite co-bonded T stiffened panels with thermoset materials in autoclave according to the aeronautical standards.
- Strong background in the modelization of composite structures. Experience in developing failure criteria aimed at supporting design and sizing of composite structures.
- Significant skills and experience in design, sizing and certification of composite primary structures for aeronautics.
- Extended experience in testing composite structures at the component level.
- Availability of test equipment and infrastructure suitable to perform mechanical test of panel components. Capacity to apply damage and environmental conditions.

III. Innovative solutions for metallic ribs or fittings introduced in a composite box to optimally deal with thermo-mechanical effects

Type of action (RIA or IA)	RIA		
Programme Area [SPD]	AIR		
(CS2 JTP 2015) WP Ref.	WP A-3.1		
Indicative Funding Topic Value (in k€)	750		
Topic Leader	Dassault Aviation	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	30	**Indicative Start Date**[41]	Q4 2017

Topic Identification Code	Topic Title
JTI-CS2-2017-CfP06-AIR-01-27	**Innovative solutions for metallic ribs or fittings introduced in a composite box to optimally deal with thermo-mechanical effects**
Short description	
The objective of this CfP is to develop a thorough understanding of the thermo-mechanical behaviour of a hybrid box with composite panels but including metallic ribs or fittings. A building-up approach, from different materials CTE characterization up to the validation of a whole box assembly section, is required to develop and validate the capacity to properly modelize the thermo-mechanical effect in hybrid assemblies. Based on this developed methodology, innovative solutions will be studied for the metallic components of a composite wing-box.	

[41] The start date corresponds to actual start date with all legal documents in place.

1. Background

It is usual to maintain a number of metallic components in the definition of a composite box. However, the mismatch of different components CTE leads to thermal loads which must be carefully taken into account in addition to the static and fatigue loads commonly defined for the structure.

A classical solution is to maintain the ribs in aluminium within a composite box. Since they are oriented perpendicularly to the main direction of the loads of the box, the thermal and general loads do not add up. However it still comes with a noticeable weight penalty due to the justification in fatigue and damage tolerance of the thermo-mechanical loads. The typical solution is to add horizontal stiffeners acting as crack arresters. In the direction of the main loads (for instance spars), the thermal effect is superimposed to the general loads. This leads in several cases to the use of titanium instead of aluminium to reduce the CTE mismatch with carbon fibers and therefore the thermally induced loads.

To optimize the design of these metallic parts, it is necessary to have the best understanding of the thermally induced loads of the hybrid assemblies.

The main purpose of the activity is:

1. to provide an accurate characterisation of the hybrid composite box thermal behaviour, starting with a thorough CTE evaluation of materials and in particular composite through the full temperature range, taking into account laminate effect, moisture effect, etc.
2. to study the thermal influence at the component and assembly levels (closed box) to validate the modelization of thermal loads. The component level shall allow to properly identify the sliding behaviour of an assembly of two components (taking into account typical assembly parameters such as fasteners, tolerances, liquid shim, sealant, paint, etc.). Larger closed boxes shall provide a global validation of how the different components react and adjust with thermal loading.
3. to develop the modelization in parallel of physical testing to demonstrate the capability to correctly evaluate the thermal behaviour of a composite box housing metallic components. A thermo-mechanical characterisation of complete box sections is expected to validate the modelization capability.
4. To perform a design phase, following and based on the previous points, to propose new solutions for ribs and another type of metallic component, such as a spar, selected with the Topic Manager (optimisation of the actual architecture or new design such as topological solutions bearing in mind the combination of the thermal constraints with other loads).

The Topic Manager will provide the initial composite box configurations and materials, as well as typical constraints (thermal limits, other structural loads, sizing rules, margin policy...) as the reference.

2. Scope of work

Tasks		
Ref. No.	***Title – Description***	***Due Date***
WP1	Thermal characterisation of composite box components	T0+20
WP2	Modelization of the thermal behaviour of hybrid assemblies	T0+24
WP3	Development of improved metallic ribs and fittings	T0+30

WP1 – Thermal characterization of composite box components

The purpose of WP1 is to characterize the different materials of a hybrid composite assembly box with respect to thermal behaviour. The CTE anisotropy shall be assessed through the full range of temperature. Anticipated materials for assemblies are aluminium alloys, Ti6-4 and prepreg CFRP material such as M21EV/IMA and will be defined by the Topic Manager. The main effort needs to be achieved on the composite materials by evaluating different lay-ups and taking into account the worse environmental conditions.

In a building block approach, sub-assemblies of the different components shall be manufactured and tested to evaluate the influence of sliding and adaptation on the load profile of components, taking into account parameters such as drilling tolerances, fasteners, liquid shim, sealant, paint.

Finally a complete validation article of a box section shall be manufactured and tested for two typical metallic components (a rib and a section of titanium spar in the longitudinal direction). These larger scale tests will include characterisation of the thermo-mechanical behaviour in the full range of temperature. The achievement of thermo-mechanical cycling should be also considered to assess the possible evolution of the behaviour after a number of thermic cyclings.

The Topic Manager will provide the full definition of these two large scale components (typical configurations, materials, geometries, sizing, etc.).

The applicant shall:

- define a test programme and test procedure for the different phases of the building block approach from elementary CTE measurements to larger scale assemblies.
- manufacture the components as defined in the test programme.
- perform the tests (necessary instrumentation shall be defined, a particular attention must be given to the implementation of strain gage to withstand and compensate for a large temperature range).

WP2 – Modelization of the thermal behaviour of hybrid assemblies

The objective of this WP is to develop a methodology to properly modelize the thermo-mechanical behaviour of hybrid assemblies.

The tests performed in WP1 will be the inputs to define the proper CTEs laws of the different components to carry out the modelization. A thorough analysis of the composite results will be achieved to generate properties at the lamina level able to provide laminate values for a full range of lay-ups. Environmental effect on CTE (moisture and temperature) shall also be appraised.

The different levels of test complexity will be used to develop and validate a methodology to modelize the thermal effect of typical hybrid assemblies. The particular effect of thermal load release through sliding and adaptation at the interface (with proper interface parameters such as liquid shim, sealant, paint and fasteners tolerances) shall be studied and integrated in the modelization.

The final validation will be achieved comparing the models to the two large scale tests.

The outcome of WP2 shall be a set of validated CTE and adaptation laws and a methodology to accurately reproduce the thermal loads within a finite element model.

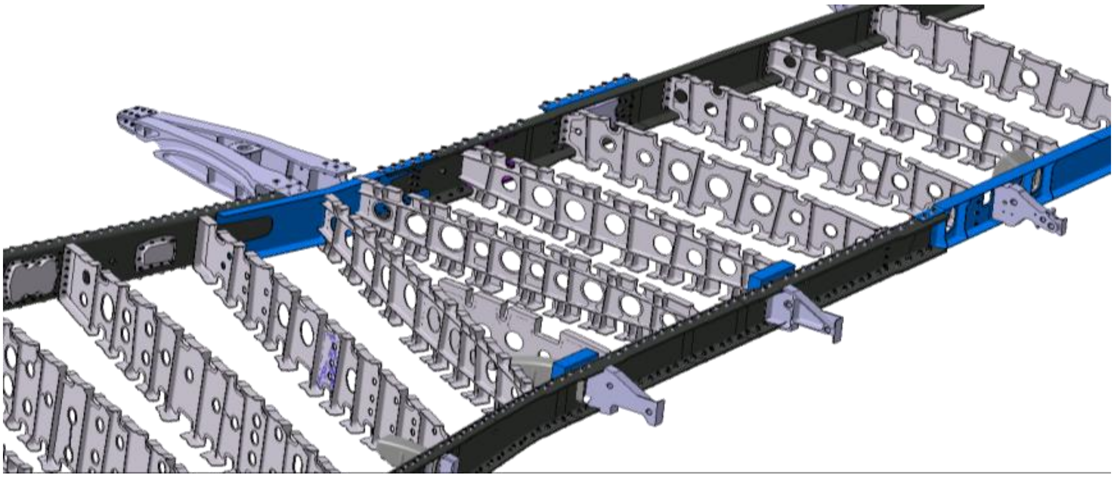
WP3 – Development of improved metallic ribs and fittings

The methodology developed from the previous WPs shall be used to generate procedures or simple tool for the design phase, providing exact thermal stress data on hybrid structure, and supporting the stress substantiation of the full structure.

This developed capacity shall be used to achieve a design exercise on two assembly configurations provided by the Topic Manager.

The baseline configuration will be revisited to try to provide improved solutions to limit the weight penalty incurred by the thermal loads. The stress analysis shall have to take into account static and fatigue aspects of both thermal and flight loads. Detailed design of the components and stress substantiation will be provided.

This WP will be carried out in strong cooperation with the Topic Manager who will provide support regarding multi-disciplinary constraints of a wing panel including loads definition, margin policy, failure criteria and sizing methodologies. The improved designs will be joint results to be shared with the Topic Manager.



Possible metallic components in a composite wing (blue and grey)

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1.1	Test definition		T0+3
D1.2	Elementary and sub-component tests results		T0+12
D1.3	Larger scale tests results		T0+20
D2.1	Methodology for thermal loads modelization		T0+24
D3.1	Innovative metallic component design for hybrid assemblies		T0+30

*Types: R=Report, D-, HW=Hardware

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1.1	Validation of CTE and adaptation laws		T0+14
M2.1	Readiness of methodology for thermal loads		T0+24
M3.1	Innovative design review		T0+28

*Types: R=Report, D-Data, HW=Hardware

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

- Experience and capability to manufacture composite panels with thermoset materials in autoclave according to aeronautical standards.
- Experience, test equipment and environment suitable to perform climatic tests of coupons, sub-assemblies and hybrid large structures. Expertise in strain measurement in a large temperature domain (+80°C to -50°C).
- Strong background in the modelization of composite structures. Experience in thermal analysis of composite structures.
- Knowledge in design, sizing and certification of composite primary structures for aeronautics.

5. Abbreviations

CTE Coefficient of Thermal Expansion

IV. Optimized cockpit windshields for large diameter business aircrafts

Type of action (RIA or IA)	IA		
Programme Area [SPD]	AIR		
(CS2 JTP 2015) WP Ref.	WP A-3.2		
Indicative Funding Topic Value (in k€)	900		
Topic Leader	Dassault Aviation	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	48	**Indicative Start Date**[42]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-AIR-01-28	**Optimized cockpit windshields for large diameter business aircrafts**
Short description	
The objectives of this project are to develop and optimize the windshield design and associated aircraft structure, but also the heating power consumption for the windshield anti-icing system. Developments will be realized closely to the topic manager teams, and will lead to models, coupons and scale 1 demonstrators that will be subjected to certification tests.	

[42] The start date corresponds to actual start date with all legal documents in place.

1. Background

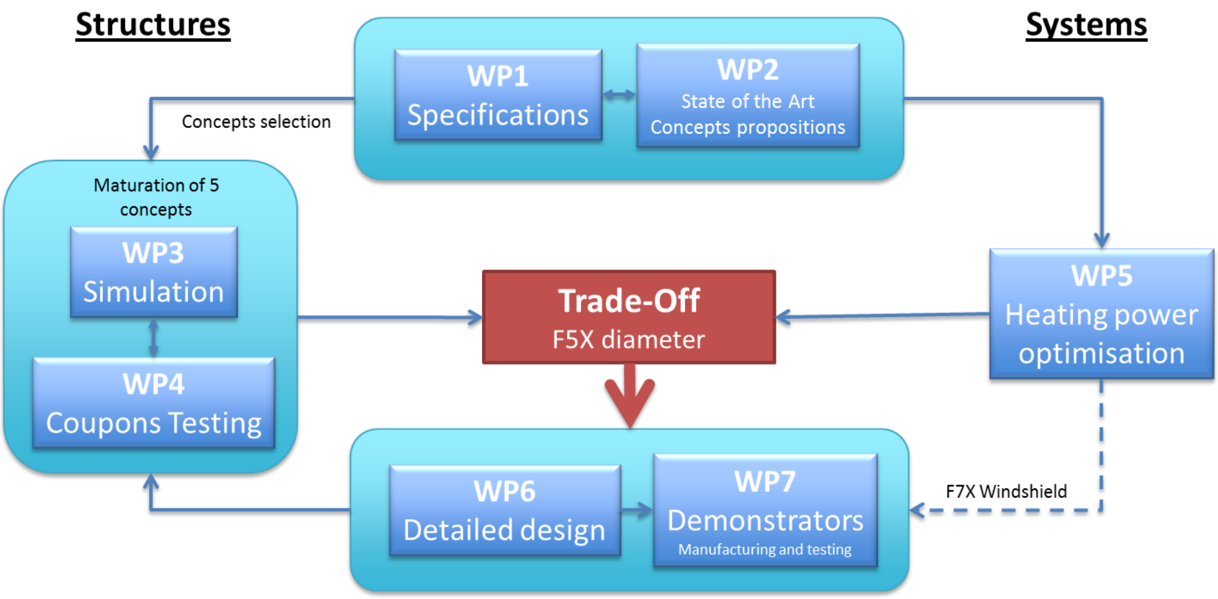
Current windshields are realized with a sandwich of glass and organic materials as interlayers, or only organic materials and a glass layer for abrasion protection. Glass windshields are clamped, and organic windshields can be clamped or bolted. However, neither of them are taken into account for the metallic fuselage structural strength development, optimisation and justification. This leads to transparencies that are only optimized for the associated certification requirements, such as bird strike which is the main mechanical stress for a windshield. Using a bolted design could allow to decrease the stress flow in the metallic fuselage by having a "mechanically working" transparency. At the end, the overall structure and transparency weight would be decreased.
Windshields de-icing heating power is currently set on an empiric value of 70 W/dm2, which is required by certification rules. However, return on experience of flight experiences and progress in heating layers manufacturing technics let envision that this heating value could be reduced or optimized through different heating zones of lower power consumption.

2. Scope of work

The final objectives of the project are:

1. To develop and optimize the windshield design and associated structure in terms of performance (technical such as weight, capacity to bear loads, acoustics, costs, maintenance, etc.)
2. To develop and optimize the heating power consumption for the anti-icing systems.

The proposed project general structure is described in the figure below:



The different tasks are synthetised in the following table:

Tasks		
Ref. No.	***Title - Description***	***Due Date***
WP1	**Specifications**	T0 + 6
WP2	**State of the Art and concepts propositions**	T0 + 12
WP3	**Simulation**	T0 + 30
WP4	**Coupons Testing**	T0 + 30
WP5	**Heating power optimization**	T0 + 24
WP6	**Demonstrator design**	T0 + 36
WP7	**Demonstrator manufacturing and testing**	T0 + 48

WP1 - Specifications

The objective of this WP is to define project goals and technical requirements according to high level specifications. Technical requirements (such as weight, capability of bearing loads, acoustics, etc.) but also costs and maintenance requirements will be considered as major topics of interest.

Figure 1: *Picture or the 5X Upper T12 coupon (transparencies not installed) used for bird strike and hail tests*

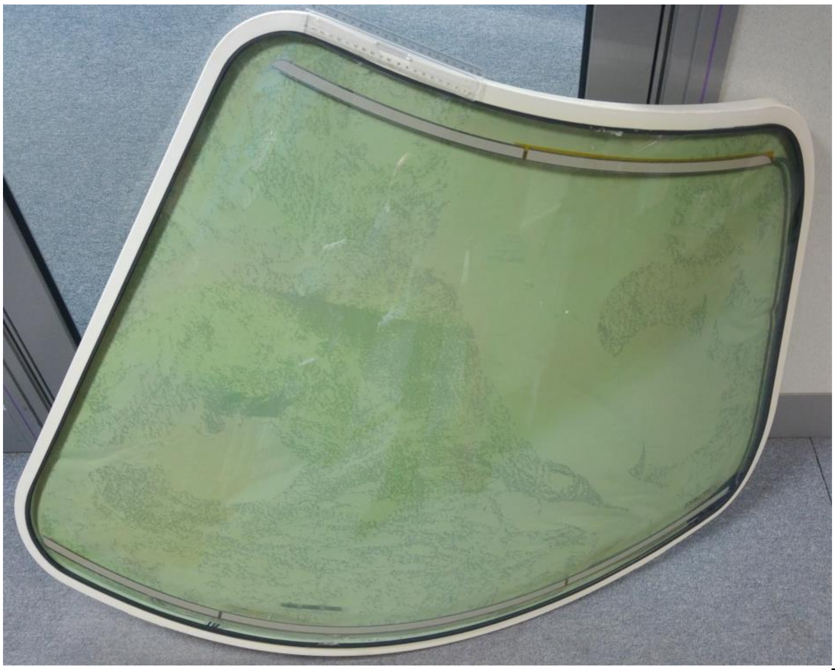


__Figure 2:__ Picture or the 5X front left windshield

WP2 - State of the Art and concepts propositions
The objectives of this WP are first to list and study State of the Art and new technologies that could be employed to improve windshields performance, then anticipate their integration in aircraft windshield, and at the end propose improved concepts and estimate performance beyond State of the Art solutions. Scope will be focused on technologies (materials, clamp or bolted designs, heating layers), but also on numerical tools and models that can help improving the design, its optimization and validation.

WP3 - Simulation
This WP will be dedicated to modeling and numerical optimization.
The first objective will be to improve state of the art models and simulation codes in order to better design structures and transparencies, and their interaction, in terms of mechanical requirements, acoustics, robustness, environmental constraints, etc. Five or more models of T12 taking into account elementary materials properties and assembly methods, and inputs from WP2, will be developed and optimized through modelling and tests results of WP4. At the end, 5 preliminary demonstrator designs for WP7 will be validated.
Studies will take place in partnership with the Topic Manager T12 design and stress teams.

WP4 - Coupons Testing
This WP will be dedicated to coupons tests (tests that do not involve the T12 structure that will be delivered by the Topic Manager in WP7) in order to feed or validate numerical analysis of WP3 with material data basis, but also to realize development coupons tests on the 5 concepts. This will permit to compare the 5 concepts in terms of mechanical behavior (bird strike, fatigue, pressure, acoustics …) for example with different assembly techniques of the transparencies to the structure.

Figure 3: *Picture of one of the 5X transparencies during pressure test*

M0 - Trade-off

This trade-off will permit to compare the 5 concepts developed and optimized in WP3 and WP4 to the main requirements from the Topic Manager: Weight, Costs (including development, recurrent, maintenance), robustness, acoustic, lifetime, etc.

After the selection process that will take place with the Topic Manager, the best concept will continue through WP6.

WP5 - Heating power optimization

The aim of this WP is to study the decrease of heating power consumption of the anti-icing and defogging systems for the front windshields (only, lateral windshields will not be considered) in terms of certification requirements. First objective will be to develop technical argues to envision a certification with a heating power density below 70 W/dm2, then demonstrate its feasibility on prototypes (in WP7, F7X windshield and a F5X windshield), and at the end consolidate technical gain and progress from the experience.

Inputs such as high level specification or typical flying conditions parameters for accreting ice and water will be given by the Topic Manager teams. Water accretion and flow models will be delivered by the Topic Manager, and developed and improved by the applicant.

WP6 - Demonstrator design

This WP aims at designing T12 detailed demonstrator design and specifying associated tests. A joint design process will take place with the Topic Manager design office.

WP7 - Demonstrator manufacturing and testing

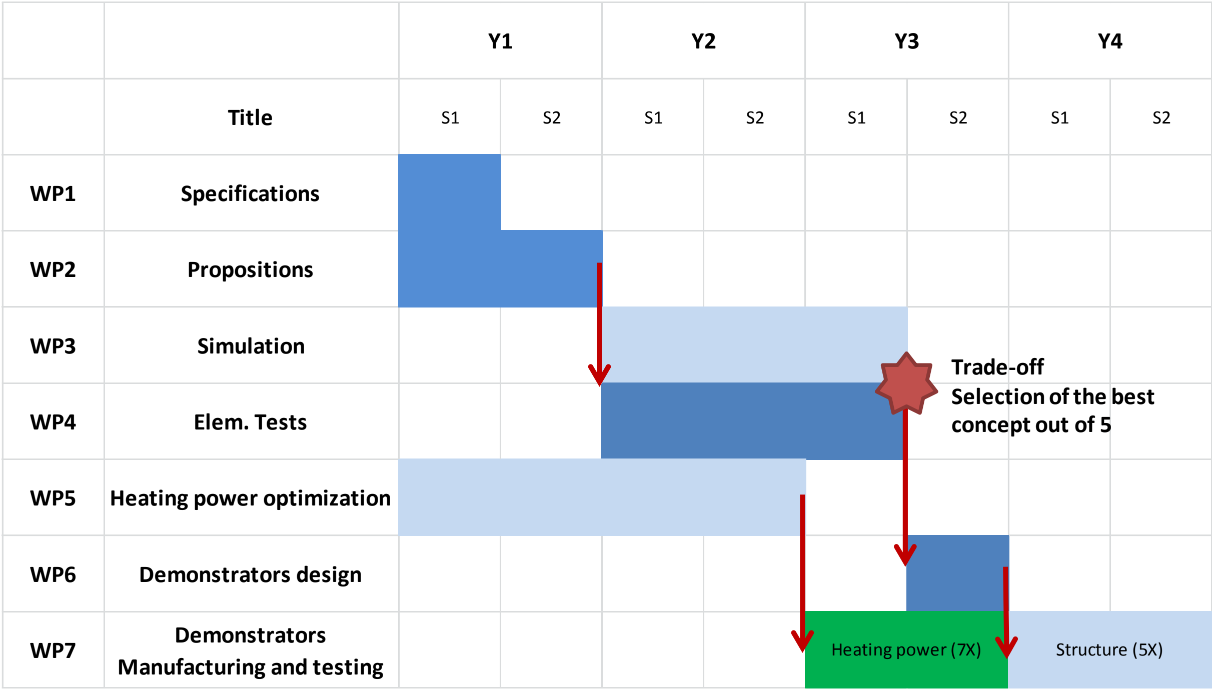
The aim of this WP is to manufacture the best selected F5X T12 concept from the trade-off, and to realize associated certification tests. The F7X windshield with the improved low power consumption heating layer will also be manufactured in this WP. Tests results will be correlated with WP3 simulations.

The T12 structure will be designed jointly with the Topic Manager, but the T12 manufacturing will be realized only by the Topic Manager (except for the transparencies).

The applicant will be in charge of manufacturing the transparencies demonstrators (and associated systems). He will then have to realize all certification tests (except the ones that were already performed in WP4).

Remark : for T12 certification tests, approximately 100 measurements canals for pressures tests and 50 measurements canals will be needed, as well as one or more high speed cameras for bird strike tests.

A preliminary overall planning is shown below:



General remarks:

- The architecture of the transparencies will be done in close cooperation with the Topic Manager teams in charge of the fuselage design.
- The development of the transparencies (shape, dimensions, interface, materials selection, etc.) has to be done in cooperation with the Topic Manager.

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1.1	General specification	R	T0 + 6
D1.2	Project detailed structure and work plan	R	T0 + 6
D1.3	Development plan for new technologies	R	T0 + 6
D1.4	Testing plans	R	T0 + 6
D2.1	State of the art and new technologies list and technical description	R	T0 + 12
D2.2	Propositions of improved concepts	R	T0 + 12
D2.3	Theoretical study of new technologies integration	R	T0 + 12
D3.1	Preliminary designs of 5 concepts for final trade-off before demonstrators studies	R + D	T0 + 30
D3.2	Study of the improvement of certification tests modeling beyond state of the art, with correlation to tests of WP4 and WP7	R + D	T0 + 30

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D4.1	Material data basis	R + D	T0 + 30
D4.2	Tests results for 5 concepts	R	T0 + 30
D5.1	Optimization methodology and conclusions	R	T0 + 24
D5.2	Technical argues to envision a certification with a heating energy below 70 w/dm2	R	T0 + 24
D5.3	Consolidated technical gain and progress	R	T0 + 24
D5.4	F7X Windshield Demonstrator design for WP7	R + D	T0 + 24
D5.5	F5X Windshield Demonstrator design for Trade-off and WP7	R + D	T0 + 24
D6.1	Detailed demonstrator design	R	T0 + 36
D6.2	Test plan	R	T0 + 36
D7.1	Scale 1 transparencies and associated systems demonstrators Remark: T12 structure will be supplied by the Topic Manager	HW	T0 + 48
D7.2	Certification tests results	R	T0 + 48
D7.3	Correlation of tests results with WP3 simulations	R	T0 + 48

*Types: R=Report, D=Data, HW=Hardware

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M0	**Trade-off** **Select the best concepts according to requirements**	R	T0 + 30

*Types: R=Report, D-Data, HW=Hardware

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 certification related activities in relation with the transparencies. Therefore, the Partner has to provide all documentation necessary to achieve “permit to fly”; to reach this goal, the Partner shall perform the following actions:

- To provide the Topic Manager with material data,
- To use materials, process, tools, calculation tools, etc. which are commonly accepted by aeronautic industry and certification authorities,
- To harmonize calculation processes/tools with the Topic Manager,
- To act actively with the Topic Manager at any state of work,
- To give access to the production and tests sites,
- To perform updates of documentation in case of insufficient documentation for authorities.

The applicant must be capable of providing data inputs for Life Cycle Analysis (LCA) to define environmental impact of technologies (energies, volatile organic compounds, waste, etc.) for important design and manufacturing milestones.
The applicant must be capable of monitoring or decreasing the use of hazardous substances regarding REACH regulation.

Special skills:
- Aerospace transparencies development, optimization, testing experiences on certified programs, and

especially the following skills:

- Modelling of bird strike test (bird model, material laws at high speed and dynamic impact),
- Transparencies / structure interactions,
- Knowledge and know-how of plugged and bolted design of windshields with all kind of transparent materials (glass with chemical reinforcement, acrylic, etc.).

- Transparencies development and certification tests set-up: bird strike, ageing, endurance, etc.

- Aerospace transparencies systems development, optimization, testing experiences on certified programs, and especially the following skills:

- Capability of modelling and experimental validation of water/ice accretion,
- Capability of designing and manufacturing a heating layer,
- Capability to define and provide electrical power converter,
- Mastering of heating layers design and optimization.

- Proven capability of the industrialization of the transparencies and associated systems in serial parts, either at the applicant production site or at another company.

5. Abbreviations

T12 Front sections of the aircraft, from nose-cone to first cylindrical section (passenger door is not included)

WP Work Package

F5X Falcon 5X aircraft from Dassault Aviation

F7X Falcon 7X aircraft from Dassault Aviation

V. Optimisation of Friction Stir Welding (FSW) and Laser Beam Welding (LBW) for assembly of structural aircraft parts

Type of action (RIA or IA)	RIA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	WP A-3.3		
Indicative Funding Topic Value (in k€)	1400		
Topic Leader	SAAB	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	30	**Indicative Start Date**[43]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-AIR-01-29	**Optimisation of Friction Stir Welding (FSW) and Laser Beam Welding (LBW) for assembly of structural aircraft parts**
Short description	
The objective of this research topic is to achieve a lighter and low cost assembly solution for a typical aluminum aircraft assembly through designing for FSW and LBW. An important aspect is achieving cost effectivity in relatively short welds, typically 1-2m.	

[43] The start date corresponds to actual start date with all legal documents in place.

1. Background

This topic is part of Airframe ITD, Activity Line A: High performance and Energy Efficiency, TS A-3: High Speed Airframe, Work Package (WP) A-3.3: Innovative shapes & structure.

Within WP A-3.3 the Topic Manager will design and assemble a number of alternative structures highlighting the potential for future metallic manufacture methods. It is intended that friction Stir Welding (FSW), Friction Stir Spot/Stitch Welding (FSSW) and Laser Beam Welding (LBW) will be used to assemble a number of these structures. The parts to be welded will consist of frames and stiffeners, which are load bearing structural components, directly to a curved skin of a demonstrator(s).

FSW/FSSW

Development of FSW and FSSW has been progressing rapidly over the last few years and certain applications have been identified as beneficial for the aerospace industry. In contrast to conventional welding techniques where the joined components are melted to create the joint, FSW and FSSW mechanically intermixes the materials at lower temperatures. The heat affected zone and overall property degradation for FSW is therefore less than for many other welding techniques and is more comparable to fastener joining techniques in terms of strength and fatigue resistance. In general, welded joints can be performed at a higher rate than traditional fastener joints as it involves fewer process steps (no need for drilling, disassembly, de-burring, re-assembly and insertion/pulling of fasteners). Welding also allows for higher structural integration, possibly resulting in weight savings in the new design of profiles aimed for FSW and cost reduction as well as reduced environmental impact.

Different types of weld joints such as FSW corner joints, lap joints and FSSW provide different advantages and drawbacks in terms of mechanical performance, production rate, production cost and design requirements. These characteristics need to be further investigated in order to identify the most suitable option for the given application.

LBW

Manufacturing of laser welded structures are generally less labour intensive than riveted structures, offering possibilities for increased automation and reduced production costs.

A prerequisite in order to realize the potential advantages is to design the structure for welded manufacture. In addition, it is necessary to consider the selection of material and welding method. Laser beam welding offers a means to provide high quality welds in aluminium alloys and is considered a suitable welding method for primary airframe structures. The scope of this topic is limited to relatively short welds, typically 1-2m, which may be applicable in structural components like aircraft doors.

2. Scope of work

The objective of the topic is to develop cost efficient manufacturing technique(s) and reduce the weight in comparison with an equivalent riveted structure. High quality welds are required for the demonstrator and the welding is intended to be qualified (not as part of this topic) for primary structure. Aerospace grades of aluminium alloys (material to be welded) are to be defined in cooperation with the Topic Manager.

It is important to ensure that adequate mechanical performance is achieved for the welded structures in terms of stress, fatigue and corrosive properties to allow for use in aerospace applications. For this reason a substantial test program is required throughout the topic to ensure the quality of the welding and that the design solutions are feasible from a future airworthiness perspective.

A representative door skin, frames and stiffeners will be provided by the Topic Manager, it is expected that the winning applicant assemble the structural components with a combination of FSW, FSSW and LBW. Which parts and profiles shall be discussed and agreed with the Topic Manager making best use of the Topic Manager's experience in aircraft design and the welding expertise of the winning applicant.

A number of different geometries for the parts to be assembled and the type of welding joints shall be investigated together with the Topic Manager. T/Z profile frames and Z-shaped stiffeners are examples of typical profiles which should be considered. Heat treatment after welding is expected although not a requirement; this should be discussed with the Topic Manager with the focus being on achieving the required quality for aircraft structures. Any interfay sealant requirements will also need to be considered and if necessary combined with the welding. An important objective is to ensure that any distortions of the exterior skin (aerodynamic surface) are minimal and additional treatments after welding should be minimised.

In addition the Topic Manager will provide two curved panels which shall be joined by FSW, these panels may include additional internal structure. The schematic below shows a typical aircraft door configuration with skin, frames and stiffeners, and approximate dimensions. The demonstrators will be based loosely around the sizing and structure shown here.

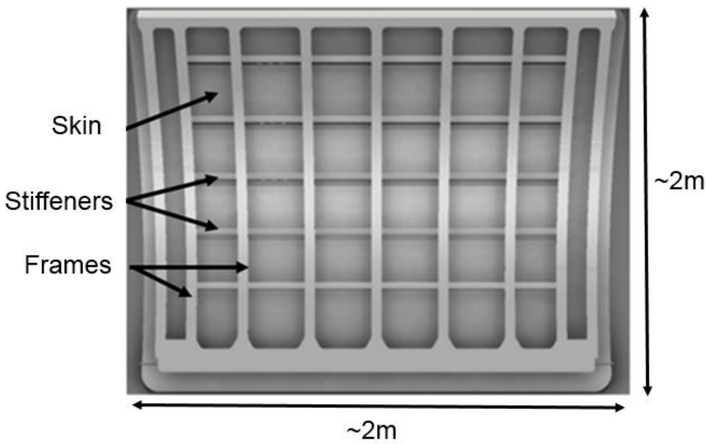


Figure 1: A typical structural configuration and size for an aircraft cargo door.

The topic is split up into the following four work packages (WP):

Work Packages		
Ref. No.	***Title – Description***	***Due Date***
WP 1	Development and manufacture of a FSW tool and process for FSW and FSSW of frames and stiffeners to skin of the demonstrator(s): **WP 1.1** Development and manufacture of a FSW tool/process to weld T-frames **WP1.2** Development and manufacture of a FSW/FSSW tool(s) for traditional profiles of frames and stiffeners	T0+25
WP 2	Development and manufacture of a LBW process to LBW frames and stiffeners to skin of the demonstrator(s): **WP 2.1** Design for manufacture **WP 2.2** Welding and fabrication of demonstrator	T0+25
WP 3	FSW of a butt joint like configuration for two curved skin panels	T0+30
WP 4	Mechanical properties and testing of welds and welded joints (all methods)	T0+27

WP1 - Development and manufacture of a FSW tool and process for FSW and FSSW of frames and stiffeners to skin of the demonstrator(s)

WP1.1 – Development and manufacture of a FSW tool/process to weld T-frames
FSW of curved, thin aluminium sheet (aircraft skin) with T-profiled frames is a relatively new and promising application of FSW. As the aerodynamics of the outer skin is to be maintained it is preferred that the rotating tool is inserted from the inner side of the skin (non aerodynamic side). This results in access difficulties to negotiate the protruding flange section of the T-shaped frames which are to be welded to the skin. Novel tooling or development of similar existing solutions shall be designed, manufactured and tested resulting in welds of the quality required for aircraft structures. Pre-study reports of tooling concepts and any effect of the welding/tooling process on material properties is an important aspect of this WP.
Two reports are required before start of tool manufacturing (see deliverables). This work package includes development of FSW & FSSW welding procedures, qualification of welding procedures, manufacturing of weld coupons and test coupons of welded joints for testing in WP4.

The final physical demonstration shall be agreed with the Topic Manager but it should be assumed that the welding of 4 full size frames to skin shall be performed (See figure 1). The grade of aluminium to be welded for the final demonstrator (for the skin and frames) will ultimately be decided by the Topic Manager, however the chosen grade will be partially dependent upon recommendations and findings during this work package. Entry and exit points for the FSW rotating pin need to be considered and this must be taken into account either in the design of the parts or in the FSW solution provided.

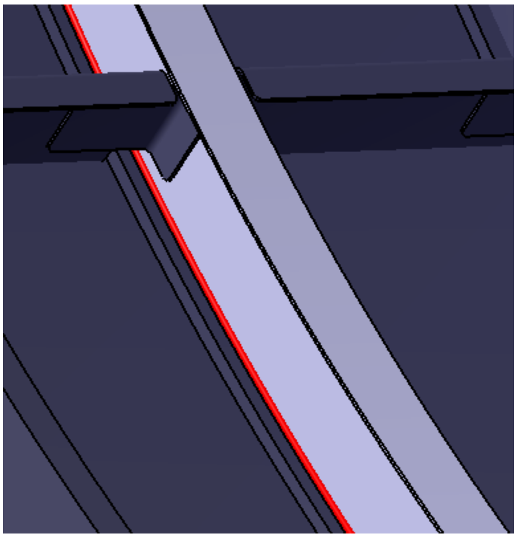


Figure 2: Schematic of a typical T-profile frame welded against a skin with FSW. The anticipated weld position is shown in red

WP 1.2 – Development and manufacture of a FSW/FSSW tool(s) for traditional profiles of frames and stiffeners

WP 1.2 shall identify an appropriate manufacturing method/process for traditional frame and stiffeners profiles (Z, C, I etc., see figures below) to be welded against a curved skin panel. Both traditional FSW and FSSW shall be considered and demonstrated. This work package includes development of FSW & FSSW welding procedures, qualification of welding procedures, manufacturing of weld coupons and test coupons of welded joints for testing in WP4. The grades of aluminium to be investigated shall be discussed together with the Topic Manager but a number of different grades are again to be anticipated.

The final physical demonstration shall be agreed with the Topic Manager but it should be assumed that the welding of 4 full size frames and a number of stiffeners (welded to skin) shall be performed (see Figure 1). The grade of aluminium to be welded for the final demonstrator (for the skin, stiffeners and frames) will ultimately be decided by the Topic Manager, however the chosen grade will be partially dependent upon recommendations and findings during this work package. Entry and exit points for the FSW rotating pin need to be considered and this must be taken into account either in the design of the parts or in the FSW solution provided.

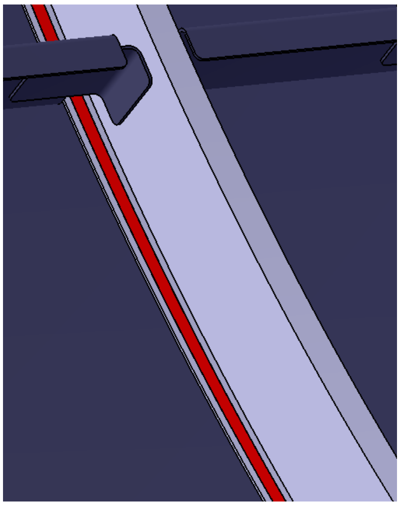


Figure 3: Schematic of a typical Z-profile frame welded against a skin. The rough weld position is shown in red. Note that the position of FSSW would be in regular intervals along this line

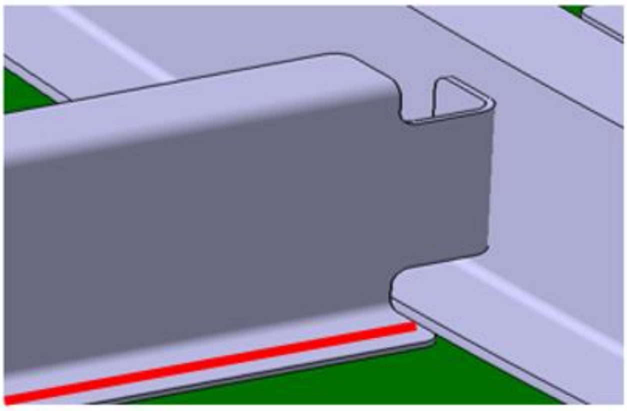


Figure 4: Schematic of a typical Z-profile stiffener welded against the skin. The weld is shown in red in the picture Note that the position of FSSW would be in regular intervals along this line

WP2 - Development and manufacture of a LBW process to LBW frames and stiffeners to skin of the demonstrator(s)

WP2.1 – Design for manufacture

The objective of this work package is to review the design of the demonstrator(s) and material selection in order to achieve laser welded joints with the required properties and to minimize for example residual stresses and distortion. The proposed design shall, in cooperation with the Topic Manager, be reviewed and optimized for welding based on state of the art technical knowledge. Necessary design or material changes or improvements shall be identified and implemented after approval from the Topic Manager. The Topic Manager defines the overall design of the demonstrator and the overall design of the structure to be welded, however suitable profiles for the frames and stiffeners which are to be welded to the curved skin shall be discussed and agreed between the Topic Manager and call partner.

The design review and report shall elaborate on subjects such as selection of parent and filler materials and on the management of residual stresses by e.g. welding procedure, post treatment and joint design. Further, the mechanical properties of the welded joint, i.e. static and fatigue properties, and corrosion properties are of interest for the study. Areas to be considered during design reviews are the design of welded joints, material and filler selection, strength and fatigue properties, and management of residual stresses and dimensional stability (tolerances, distortion).

Simulations of the complete assemblies may be performed to study the general effect of joint design and geometry upon residual stresses obtained after welding and on stress concentration levels obtained from loading of the structure during operation of the aircraft.

The deliverables from the work package are reports covering the technical assessments, design changes and design review.

WP 2.2 – Welding and fabrication of demonstrator
This work package includes laser welding activities that are going to be performed in the proposed project. These include development of welding procedures, qualification of welding procedures, manufacturing of weld coupons and test pieces of welded joints for testing, and the fabrication of the demonstrator.
The deliverables from the work package are qualified welding procedures, test coupons and test pieces of welded joints, non-destructive testing procedures and reports, and welding of the parts on the demonstrator door. The final physical demonstration shall be agreed with the Topic Manager but it should be assumed that the welding of 4 full size frames and a number of stiffeners (welded to a curved skin panel) shall be performed (see Figure 1).

WP 3 – FSW of a butt joint like configuration for two curved skin panels
The Topic Manager will provide two curved panels which shall be joined by FSW, these panels may include additional internal structure. The call partner shall perform a FSW joint in the way of a butt joint along with the length of the curved skin. The two panels to be joined can be assumed to be in the region of 1m x 2m each (the curved skin panel in Figure 1 split into two, centrally in the longitudinal direction). Again heat treatment after welding is expected (in order to achieve the correct panel shape after welding) although not a requirement, the focus being on achieving the required geometry (within the tolerances provided) and quality for aircraft structures. An important objective is to ensure that any distortions of the exterior skin (aerodynamic surface) are minimal and additional treatments after welding (and if necessary heat treatment) should be minimised. Entry and exit points for the FSW rotating pin need to be considered and this must be taken into account either in the design of the skin panels or in the FSW solution provided.

WP 4 – Mechanical properties of welds and welded joints
This work package consists of the testing and examination activities in the project. This shall include mechanical testing, fatigue testing, hardness surveys, microstructural examination and corrosion testing of weld coupons (the call partner will be responsible for procuring the material for the test coupons) from the welding qualification and welded joints in the test coupons. Work package 1 and 2 supply the required samples for the testing. The test procedures and their relevant standards shall be

agreed with the Topic Manager.
Non-destructive testing (radiographic testing, ultrasonic testing, eddy current and penetrant testing) of the welds shall be performed. A report and initial investigation is also expected regarding how NDT would be best incorporated into the manufacture process for both FSW and LBW ensuring that the cost impact of NDT is maintained to a minimum whilst providing the required quality assurance that the aircraft industry requires. The test procedures and their relevant standards shall be agreed with the Topic Manager.
Additional deliverables from the work package are testing procedures and test reports.

3. Major deliverables/milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 1.1.1	Pre-study of tool concept	Report	T0+5
D 1.1.2	Test coupons to WP4	Physical delivery	T0+20
D 1.1.3	FSW/FSSW frames with T-shape of a part of the demonstrator(s)	Physical delivery	T0+25
Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M 1.1.1	Tooling design frozen	CAD Model	T0+8
M 1.1.2	Tool manufactured	Physical	T0+12
M 1.1.3	FSW/FSSW procedures qualification completed for T-shaped frames	Approval	T0+20

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 1.2.1	Pre-study of tool concept	Report	T0+5
D 1.2.2	Test coupons to WP4	Physical delivery	T0+20
D 1.2.3	FSW/FSSW frames and stiffeners of a part of the demonstrator(s)	Physical delivery	T0+25
Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M 1.2.1	Tooling design frozen	CAD Model	T0+8
M 1.2.2	Tool manufactured	Physical	T0+12
M 1.2.3	FSW/FSSW procedures qualification completed of frames and stiffeners	Approval	T0+20

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 2.1.1	Pre-study of material and filler selection	Report	T0+12
D 2.1.2	Pre-study of joint design	Report	T0+12
Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M 2.1.1	Technical reports approved	Approval	T0+14

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 2.2.1	Test coupons to WP4	Physical delivery	T0+20
D 2.2.2	Laser welding of frames and stiffeners of a part of the demonstrator(s)	Physical delivery	T0+25
Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M 2.2.1	Laser weld procedures qualification completed	Approval	T0+20

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 3.1	Delivery of the welded skin panel demonstrator(s) to the Topic Manager	Physical delivery	T0+30
Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M 3.1	Manufacturing plan for mating the two curved skin panels	Report	T0+26
M 3.2	FSW of the curved skin halves	Manufacturing	T0+28

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 4.1	Test program specification (all methods)	Report	T0+12
D 4.2	Test procedures (all methods)	Procedure	T0+15
D 4.3	Mechanical testing (all methods)	Report	T0+21
D 4.4	Testing of welded joints (all methods)	Report	T0+27
Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M 4.1	Test program and procedures (all methods)	Approval	T0+15
M 4.2	Testing for procedure qualification reported (all methods)	Approval	T0+24
M 4.3	Testing of welded joints reported (all methods)	Approval	T0+27

D = deliverable, M = milestone

4. Special skills, capabilities, certification expected from the applicant(s)

Special expected skills are:

- Proven experience in friction stir welding (preferably <2mm aluminium).
- Proven experience in friction stir spot welding (preferably <2mm aluminium).
- Proven experience in FSW and FSSW tool design.
- Proven experience of laser beam welding.
- Solid knowledge in design of welded aluminium structures consisting of sheet and frames.
- Proven experience of simulation of welding regarding residual stresses and distortion.
- Proven experience of structural and fatigue analysis of weld joints and complete component.
- Proven experience of manufacturing of aluminium structures for the aerospace industry.
- Knowledge in material selection and welding metallurgy for aluminium alloys.
- Knowledge in strength and fatigue testing of weld samples and test pieces of welded joints.
- Experience in technological research and development for innovative products and processes.
- Experience of working with airframe designers, tooling design and joint design.
- Experience of working with suppliers of aluminium plates.
- Experience in deformation and damage mechanisms of metallic materials and structural strength modelling.
- Proven experience in collaborating with aeronautical companies Research and Technology programs.

The applicant(s) are required to have access to the following capabilities:

- CATIA CAD software, V5 R24 or later, for design compatibility with the Topic Manager
- Friction stir welding for aluminium
- Friction stir spot welding for aluminium
- Laser beam welding for aluminium
- Suitable simulation software for welding process
- Suitable manufacture and machining facilities for FSW, FSSW and LBW
- Suitable prototype workshop
- Heat treatment facilities
- Simulation software for structural analysis of the weld joints and complete structure
- Laboratory facilities for mechanical testing, residual stress measurements, metallurgical examinations, and corrosion testing
- Facility for strength and fatigue testing of welds and welded joints
- Non-destructive testing (radiographic, ultrasonic, eddy current and penetrant testing).

VI. Integration of innovative ice protection systems into structure and their validation

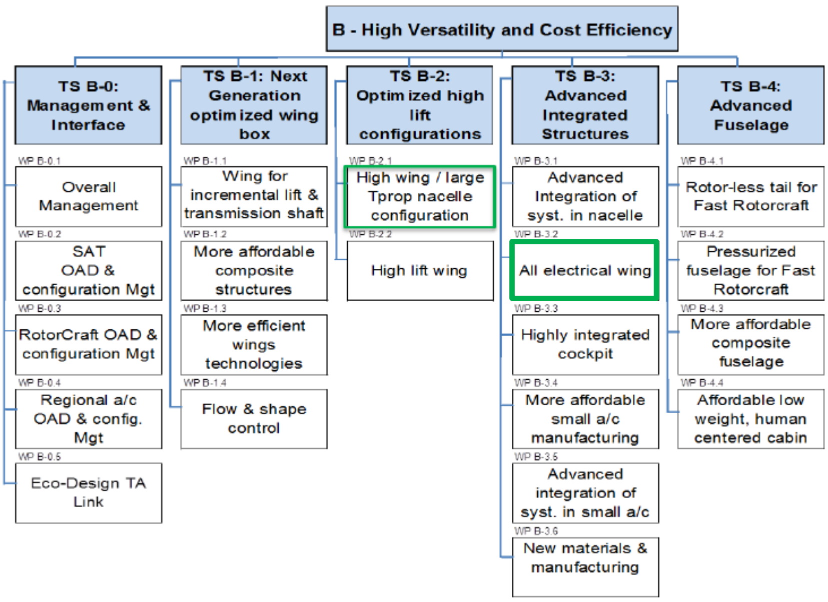
Type of action (RIA or IA)	RIA		
Programme Area	AIR		
(CS2 JTP 2015) WP Ref.	B-2.1 & B-3.2		
Indicative Funding Topic Value (in k€)	1200		
Topic Leader	Airbus D&S	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[44]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-AIR-02-39	**Integration of innovative ice protection systems into structure and their validation**
Short description	
The main purpose of this call is the integration of innovative Ice Protection systems in the structure: electromagnetic induction on composite material wing leading edges and two-phase system in the metallic engine air intake. The innovation and challenge is to find the most efficient design for the integration. In order to validate the selected technology solution, the development of Wind Tunnel Models, as well as Wind Tunnel tests in Icing conditions, of representative Nacelle and Wing and Flap Leading Edge surfaces with new Ice Protection Systems developed as technology lines within Airframe ITD framework shall be performed.	

[44] The start date corresponds to actual start date with all legal documents in place.

1. Background

This topic deals with the definition of the best integration strategy with the structure of two novel ice protection systems being defined in the frame of CS2 Airframe ITD. For the first system (two-phase heat transport), the condensing fluid lines will have to be integrated in a very complex (and tight space) surfaces such as an engine air intake for a turboprop aircraft. For the second system (electromagnetic induction), the coils and temperature sensors will also have to be integrated in a very complex and tight space surface such as wing leading edge surfaces and, in addition, the wing leading edge needs to provide appropriate cooling path to the modular power converter. This activity will be performed by the Partner of this Call in a cooperative process with the Topic Manager to ensure proper assurance of requirements.
Airframe ITD activities include definition and demonstration up to TRL5 of two innovative type ice protections systems for turboprop aircraft; one based on two-phase heat transport for an engine air intake (included in Work Package AIR B-2.1 High Wing Large TurboProp Nacelle Configuration) and a second based on electromagnetic induction for a wing leading edge (included in Work Package AIR B-3.2 All Electrical Wing).



The definition of the two systems is already underway by the Topic Manager with respective Partners (reference JTI-CS2-2015-CFP02-AIR-02-08 for two-phase system and JTI-CS2-2015-CFP02-AIR-02-11 for induction system).

The TRL5 demonstration of the technology application is intended to be performed in icing wind tunnel. For this, three instrumented demonstrators (one for two-phase and two for induction) shall be built by the Partner of this Call. A key element for those will be the representativeness of the heated surface, the integration of system to structure and the heat sources simulation.

The Partner of this Call will be also responsible for the procurement of the icing wind tunnel facility, correct integration of the demonstrators in the tunnel and support during the tests with respect to the demonstrator operation and troubleshooting. A pressurised tunnel is not needed. In the response to the Call the achievable pressures, speeds and icing envelopes in the tunnel shall be clearly indicated. Calibration data (preferably following SAe ARP 5905 “Calibration and Acceptance of Icing Wind Tunnels”) shall be also included in the response to this Call.

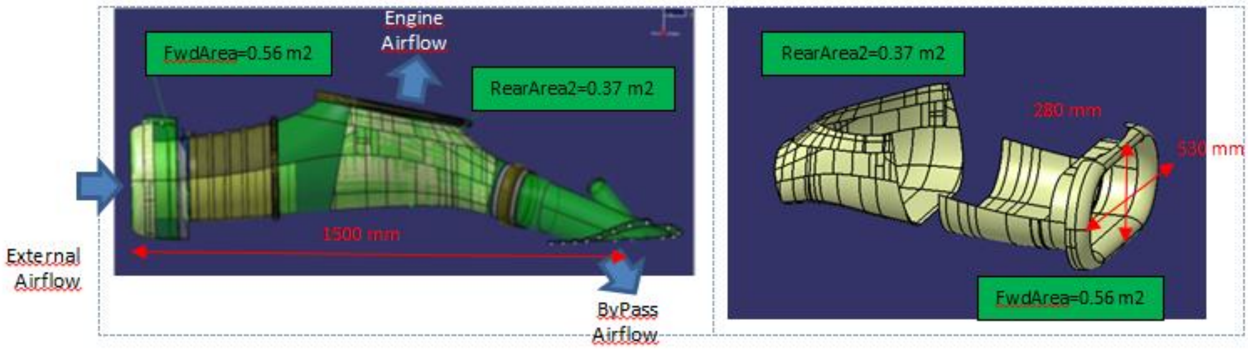
2. Scope of work

Two-phase heat transport ice protection

A typical two-phase heat transport device consists of evaporator, condenser and two transport lines (vapour and liquid). It can be completely passive that start to operate when sufficient energy is applied at the evaporator. In the same way, the heat transport stops when heating power is removed.

Two-phase heat transport technology can be used as a way to recover waste energy from A/C systems and/or components by using this heat to prevent ice formation in the surface to protect. Due to proximity to major waste heat sources, it was decided that the surface to protect is an engine air intake with a heat source able to reach up to 250 deg C and heating power of 30 Kwatt. However, the heated surface will not exceed 100 deg C with system in operation.

Below is a picture with the intake geometry with areas to be protected.

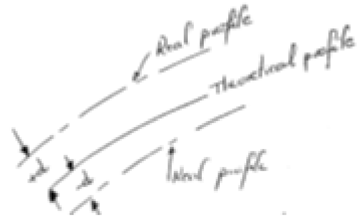
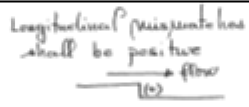


A key element in the definition of the system will be the proper integration (different options are under consideration: fluid lines attached on top of surface, embedded in channels,…) of the condensing lines in the intake so that heat is appropriately transferred and distributed from the two-phase working fluid to the aerodynamic surface of the intake. The theoretical definition / requirements of such integration will be provided by the Topic Manager but the detailed definition (together with the method of construction) is part of the work to be developed by the Partner.

Once the heated surface definition is performed, the next Partner activity will be the definition and construction of the system icing wind tunnel demonstrator. This shall include: 1) engine air intake, 2) instrumentation, 3) intake cowling simulation (including intake bypass exhaust duct), 4) hot surface generation pad and 5) system. All elements except item 5) are to be delivered by the Partner. In addition, the assembly of the condensing lines to the intake shall be an activity to be carried out by the Partner working in the definition of the system. Then, the whole demonstrator will be delivered by the Partner to the icing wind tunnel facility.

The intake shall be constructed of Aluminium material 2024 T6 with a nominal thickness of 1.2 mm to which the condensing lines will be integrated (condensing lines may be of different material to assure compatibility with two-phase fluid).

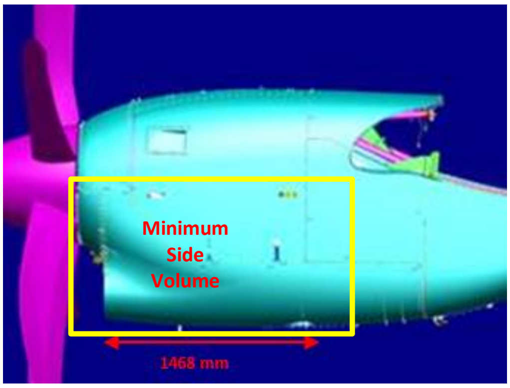
The intake acceptable aerodynamic surface tolerances shall be as follows:

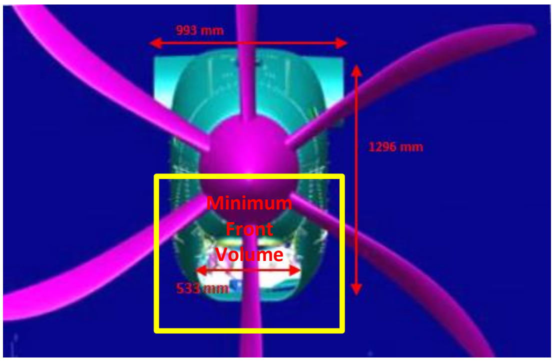
 dmax = 2 mm	 (f/L)max =1/200	 Gap max = 1 mm Mismatch max = 2 mm

Conformity to these tolerances shall be performed during Acceptance Test of the model prior to entering the icing wind tunnel. Appropriate methodology shall be provided by the Partner of this Call.
The instrumentation (to be provided as part of the model) shall include the following sensors:

1) 30 surface temperature distributed at the aerodynamic side of the intake and at the hot surface generation pad (the sensor will not protrude into the aerodynamic flow),
2) 10 surface heat transfer coefficients distributed at the aerodynamic side of the intake (the sensors will not protrude in the aerodynamic flow),
3) 10 surface static pressures at the aerodynamic side of the intake,
4) 5 ambient temperature distributed inside the intake cowlings,
5) 3 internal intake video cameras at the intake aerodynamic side,
6) 2 external video cameras pointing to the model from tunnel walls,
7) 1 thermography camera pointing to intake lip from above
8) The intake aerodynamic surfaces shall be painted and gridded with colours so that ice can be seen and spotted with external video cameras.

The intake will be surrounded by a cowling (minimum volume at icing wind tunnel highlighted in the figure below) which will simulate effect of nacelle installation in the intake water impingement, protect the intake of the tunnel conditions and provide a ducting to the airflow through the intake. The cowling will be airtight not allowing external flow to enter into nacelle. Past experience indicate that propeller spinner shall be also included in the model.





The tunnel facility shall have the capability to control intake airflow to be set at different values while keeping fixed conditions at tunnel test section.
The hot surface generation shall be based on hot air able to reach an inlet temperature of 250 deg C with a heating power of 30 Kwatt from a cylindrical surface ∅62.5 x 175 mm. and flow of 250 grm/sec The inlet temperature shall be controllable between 100 deg C and 250 deg C.
The (preliminary) icing testing campaign shall include the following test points (all at 20 microns

MVD, zero angle of attack and zero side slip angle):

Test Point	External Temp (deg C)	External LWC (grm/m3)	External Airspeed (m/sec)	Intake Airflow (Kg/sec)	Source Temp (deg C)
1	-30	0	100	4.5	250→200→150
2	-30	0.2	100	4.5	250→200→150
3	-30	1.0	100	4.5	250→200→150
4	-30	0	100	3.0	250→200→150
5	-30	0.2	100	3.0	250→200→150
6	-30	1.0	100	3.0	250→200→150
7	-10	0	100	9.0	250→200→150
8	-10	0.5	100	9.0	250→200→150
9	-10	2.2	100	9.0	250→200→150
10	-10	0	100	5.0	250→200→150
11	-10	0.5	100	5.0	250→200→150
12	-10	2.2	100	5.0	250→200→150
13	Conditions depending on results for above test points				
14	Conditions depending on results for above test points				
15	Conditions depending on results for above test points				

The (preliminary) procedure for each of all points will be the following:

1) Set the external and intake airflow conditions,
2) Apply heating changing hot source temperatures until steady state conditions,
3) Stop heating and external and intake airflow to inspect the ice remaining.

<u>Electromagnetic induction ice protection</u>

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, heating by induction has not been used in aircraft application but seems very suitable and with good potential for heating composite laminate structure which include metallic materials. In this case there are two surfaces to protect made in composite laminate with embedded metallic mesh:

1) wing leading edge, for technology validation and carry out the needed activities to TRL5.

2) flap Gap leading edge. This second option is selected by the Topic Manager for Exploitation purposes to be performed by the Topic Manager with collaboration with the Partner. The main objective is the technology validation and bench-marking of the system in other airfoil configurations, such as defined below.

There will be two separate models to demonstrate the technology application.

A key element in the definition of the system will be the proper integration in the leading edges of:

1) the coils (so that heating of the grid is as expected),
2) the system surface temperature sensors (so that heating cycles are well defined), and
3) the power converter in the leading edge (so that power electronics is appropriately cooled).

The theoretical definition/requirements of integration for all elements will be provided by the Topic Manager but the detailed definition (together with the method of construction) is part of the work to be developed by the Partner.

The wing leading edge demonstrator shall include: 1) composite wing leading edge, 2)

instrumentation, 3) simulated wing section and 4) system. All elements except item 4) are to be delivered by the Partner. The Topic Manager will deliver item 4) (consisting of coil mats, temperature sensors and power converter) to be assembled in the demonstrator by the Partner.
The leading edge aerodynamic surface geometrical definition will be based on a NACA 0018 profile with a chord of 2 metres. It shall be constructed as depicted below:

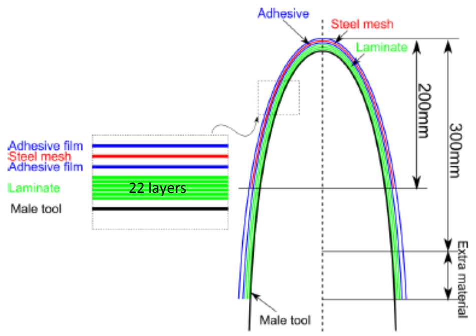
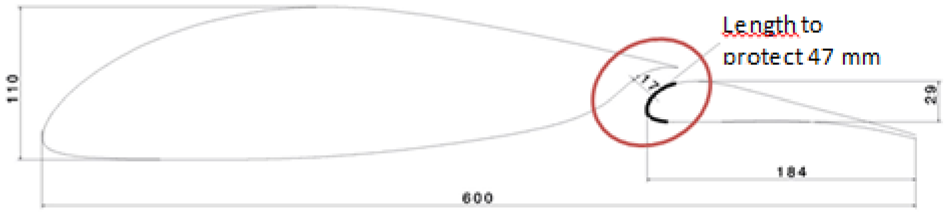


Table 1. Materials

N°	Designation	Material specification
1	Carbon epoxy prepreg fabric (HS5) 180°C curing temperature	ABS 5003 B0000-03 AIMS 05-01-004
2	Structural epoxy adhesive film for composite bonding (FM300)	ABS 5320 BK02 AIMS 10-01-006 B
3	Stainless steel mesh (SS316L)	3SS(316L)8-077A (DEXMET)

The span of the leading edge composite shall be at least 1.2 metres.
The leading edge will be completed with a wing section defined so that leading edge water impingement is representative of a wing profile about 2 metres chord. The section will not have twist nor sweep along the span.
The flap leading edge demonstrator is defined in order to explore the technology capabilities in other wing configurations and other locations to be protected. The model defined below shall include: 1) composite flap, 2) instrumentation, 3) simulated wing section and 4) system. All elements except item 4) are to be delivered by the Partner. The Topic Manager will deliver item 4) (consisting of coil mats, temperature sensors and power converter) to be assembled in the demonstrator by the Partner.
The overall dimensions of the wing section to be simulated are in the figure below.



The flap shall be attached to the main section with the capability of being fixed at different angular positions (between –x deg and +x deg) with respect the main section prior to each test point in icing wind tunnel. Passages of cables from main profile section to flap shall be considered in the attachments.
The span of the model will be as a minimum 1.2 metres without sweep nor twist.
The flap shall be constructed similarly to the wing leading edge.
The acceptable aerodynamic surface tolerances for the whole wing section in the two demonstrators shall be, as a minimum, as follows:

 dmax = 2 mm	 (f/L)max =1/200	 Gap max = 1 mm Mismatch max = 2 mm

Conformity to these tolerances shall be performed during Acceptance Test of the model prior to entering into the icing wind tunnel. Appropriate methodology shall be provided by the Partner of this Call.

The instrumentation (to be provided as part of each of the two models) shall consist of the following sensors:

1) 25 surface temperature distributed in 5 sections at the aerodynamic side and internal side of leading edge (the aerodynamic side sensors will not protrude into the external airflow and in contact right below the metallic mesh),
2) 10 surface heat transfer coefficients distributed at the aerodynamic side of the leading edge (the sensors will not protrude in the aerodynamic flow),
3) 5 ambient temperature distributed inside the leading edge,
4) 2 external video cameras pointing to the model from tunnel walls,
5) 1 thermography camera pointing to center wing section leading edge, and
6) The leading edge aerodynamic heated surface shall be painted and gridded with colors so that ice can be seen and spotted with external video cameras and not creating problems to thermography.
7) 20 Templates with the shape of leading edge to record icing shapes.

The icing tunnel facility shall be able to provide 30 Kwatt of electrical power at 270 Vdc to the system power converter. The power shall be controllable.

The (preliminary) icing testing campaign for each of the two models shall include the following test points (all at 20 microns MVD and zero angle of attack):

Test Point	External Temp (deg C)	External LWC (grm/m3)	External Airspeed (m/sec)	System Duty Cycle (sec ON/sec cycle)
1	-30	0	100	30%,50%,70%,100%
2	-30	0.2	100	Based on Test Point 1
3	-30	1.0	100	Based on Test Point 1
4	-20	0	100	30%, 50%, 70%,100%
5	-20	0.3	100	Based on Test Point 4
6	-20	1.7	100	Based on Test Point 4
7	-10	0	100	30%,50%,70%,100%
8	-10	0.5	100	Based on Test Point 7
9	-10	2.2	100	Based on Test Point 7
10	-20	0	150	30%,50%,70%,100%
11	-20	0.3	150	Based on Test Point 10
12	-20	1.7	150	Based on Test Point 10

Test Point	External Temp (deg C)	External LWC (grm/m3)	External Airspeed (m/sec)	System Duty Cycle (sec ON/sec cycle)
13	Conditions depending on results for above test points			
14	Conditions depending on results for above test points			
15	Conditions depending on results for above test points			

The (preliminary) procedure for each of all points will be the following:
1) Set the external airflow and cloud conditions,
2) Apply heating and record data for at least 10 operating cycles,
3) Stop heating and external and intake airflow to inspect the ice remaining.

A list of tasks is here provided:

Tasks		
Ref. No.	***Title – Description***	***Finished Due Date***
WP1a	***Definition of the engine air intake with integrated condensing lines***	T0+5
WP2a	**Definition of two-phase system demonstrator**	T0+10
WP3a	**Manufacturing and assembly of two phase demonstrator**	T0+19
WP4a	***Icing Wind Tunnel testing of two-phase demonstrator***	T0+24
WP1b	***Definition of wing and flap leading edge with integrated coils, sensor & converter***	T0+5
WP2b	**Definition of wing and flap induction system demonstrators**	T0+10
WP3b	**Manufacturing and assembly of wing and flap induction demonstrators**	T0+19
WP4b1	**Icing wind tunnel testing of wing induction demonstrator**	T0+24
WP4b2	**Icing wing tunnel of flap induction demonstrator**	T0+24

Key innovation aspects are highlighted below:
1) Integration of multiple condensing lines in an aluminum surface
2) Integration of wiring coils and sensors in a composite laminate concave surface
3) Cooling of the converter through the composite leading edge
4) Simulation of 30 Kwatt hot surface for a two-phase system for a icing wind tunnel

3. Major Deliverables / Milestones and schedule

		Deliverables		
Ref. No.	***nº***	***Title – Description***	***Type***	***Due Date***
WP1a	D1a.1	Metallic air intake with integrated condensing lines definition report	(D) Document	T0 + 4
WP2a	D2a.1	Definition of two-phase system demonstrator	(D) Document (with drawings)	T0 + 10

Deliverables				
Ref. No.	***nº***	***Title – Description***	***Type***	***Due Date***
	D2a. 2	Two-phase Demonstrator acceptance procedure	(D) Document	T0 + 10
WP3a	D3a. 1	Engine air intake to icing wind tunnel	(HW) Delivery	T0 + 10
	D3a. 2	Two-phase demonstrator to icing wind tunnel	(HW) Delivery	T0 + 19
	D3a. 3	Two-phase Demonstration acceptance report	(D) document	T0 + 19
WP4a	D4a. 1	Two-Phase Icing Wind Tunnel Test Plan and Procedures	(D) Document	T0 + 10
	D4a. 2	Two-Phase Icing Wind Tunnel test data	(D) Document with photos, videos and recordings	T0+24
WP1b	D1b. 1	Composite laminate WLE and FLE with integrated induction system definition report	(D)Document	T0 + 4
WP2b	D2b. 1	Definition of WLE and FLE induction system demonstrator	(D) Document (with drawings)	T0 + 10
	D2b. 2	WLE and FLE Induction Demonstrator acceptance procedure	(D) Document	T0 + 10
Wp3b	D3b. 1	Leading edge and flap to icing wind tunnel	(HW) Delivery	T0 + 10
	D3b. 2	WLE and FLE Induction demonstrator Acceptance Test report	(D) Document	T0 + 19
	D3b. 3	WLE and FLE Induction Demonstrator to icing wind tunnel	(HW) Delivery	T0 + 19
WP4b	D4b. 1	WLE and FLE Induction Icing Wind Tunnel Test Plan and Procedures	(D) Document	T0 + 10
	D4b. 2	WLE and FLE Induction Icing Wind Tunnel test data	(D) Document with photos, videos and recordings	T0+24

Milestones		
Ref. No.	***Title – Description***	***Due Date***
M0	Kick Off Meeting	T0
M1	Air intake with integrated condensing lines Design Review WLE and FLE with integrated induction system Design Review	T0+4
M2	Air Intake Two-Phase Demonstrator Design Review WLE and FLE Induction Demonstrators Design Review	T0+10

Milestones		
Ref. No.	***Title – Description***	***Due Date***
M0	Kick Off Meeting	T0
M3	Air Intake Two-Phase Demonstrator Test Readiness Review WLE and FLE Induction Demonstrators Test Readiness Review Icing wind tunnel Test Readiness Review	T0+19
M4	Final Review	T0+24

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

The Partner shall have the following proven experience:

1. Design and manufacturing of aero-structures (engine air intakes and wing leading edges)
2. Thermal design and heating systems (especially two-phase and electro-thermal)
3. Integration of thermal instrumentation in aero-structures
4. Icing tunnel experience in testing elements like the ones included in this Call. Calibration data (preferably following SAe ARP 5905 "Calibration and Acceptance of Icing Wind Tunnels") shall be mandatorily included in the response to this Call.
5. Capability of icing wind tunnel to reach testing points (speed, LWC, Temperature and MVD) shall be clearly indicated in response to this Call.

An Implementation agreement will be proposed to manage the IPR and the relation between the Topic Manager and the Applicant(s).

5. Abbreviations

A/C AirCraft
FLE Flap Leading Edge
ITD Integrated Technology Demonstrator
MED Median Effective Diameter
N/A Not Applicable
NACA National Advisory Committee for Aeronautics
TBD To Be Defined
TRL Technology Readiness Level
WLE Wing Leading Edge

VII. Enhanced Low Cost Complex Composite Structures

Type of action (RIA or IA)	IA		
Programme Area	AIFRAME		
Joint Technical Programme (JTP) Ref.	B-2.2		
Indicative Funding Topic Value (in k€)	500		
Topic Leader	Airbus D&S	Type of Agreement	Implementation Agreement
Duration of the action (in Months)	18	Indicative Start Date[45]	Q1 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CfP06-AIR-02-40	**Enhanced Low Cost Complex Composite Structures**
Short description	
The target of this CfP is to research and to develop design and manufacturing methodologies for A/C complex composite components applying Infusion (LRI) technologies in order to achieve improved primary structures in terms of weight and cost, and to enable immediate Design Office decisions for next future aircraft designs.	

[45] The start date corresponds to actual start date with all legal documents in place.

1. Background

Actually, qualified low cost manufacturing processes are sought as one of the main ways to build aircraft affordable structures.
Composite manufacturing processes for small and medium size aerostructures are featured by substantial labour effort and small automation level. This has a clear negative impact on intensive use of labour and on costs due to the use of complex tooling. In addition, the need of extremely expensive tooling and dedicated equipment make difficult to have a return on investment, which is detrimental for small-medium aircraft business case.
It is then crucial for transport aircraft OEM to reduce acquisition and ownership costs of composite structures, as it is little opportunity to do this with existing technologies. Innovative new concepts are therefore necessary to enhance current composite design and manufacturing processes. Cost and weight parts reduction can be achieved through the implementation of novel, innovative composite design technologies, materials, and manufacturing processes.
Infusion (LRI) technologies are promising in terms of overcoming above-mentioned drawbacks and achieving the desired objectives. To develop an innovative and low cost manufacturing process for infusion components to be installed in the A/C is the aim of this project.

2. Scope of work

Project goals will be achieved through the proposal, justification and selection of a technology demonstrator focused on targets compliance. It is expected to obtain up to 40% cost reduction through tooling selection and up to 20% from the innovation out of other manufacturing process. Key aspects are full integration (structure & systems) and efficient ways to solve the sealing issues.
The present topic's activities aim to close the gap between cost effectiveness in design and available technologies with regards to complex composite structures, mainly focused on transport aircraft manufacturers.
High integration reducing and simplifying the design concept, mainly avoiding fastening solutions, is one of the key aspects to bear in mind as a main path to establish the correct strategy to achieve the required earnings in weight and costs. One-shot concepts are also key.
In addition, it is important by this project to support and reinforce the maturity of infusion technology launched in Airframe ITD WP B-2.2, and it is an opportunity to de-risk the current developments via benchmarking activities.
A ground demonstrator is expected to be manufactured. The final requirements and needed features shall be met by achieving Flight Clearance whilst verifying project targets compliance.
The work to be performed is applicable to research streams described within WP B-2.2, B-3.3 and B-2.1 to complement other composite technologies being explored for wing or fuselage demonstrators manufacturing, based on composite liquid technologies.
The following main areas shall be investigated:

- Design and analysis methods (i. e., out of plane stresses approach).
- Materials and manufacturing processes, focused on cost savings.
- Tooling new concepts.
- Verification and Validation.

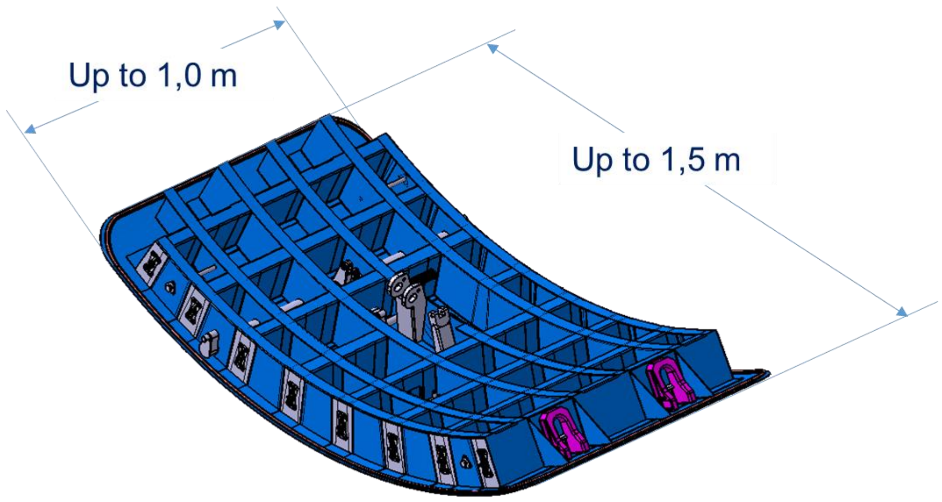
The development of tooling shall be innovative in order to meet the project targets by implementing the best performances in the following fields:

- Low Cost / Easy Manufacturing Materials, i.e. applying Additive Manufacturing Techniques.
- Eco-design, i.e. encouraging reusability and recyclability.

- Energy savings.
- Self-heating moulds (resistant, mineral oil, etc.) including a self-regulating temperature system with embedded and advanced sensors for process monitoring.
- Reduction over the overall energy consumption by optimizing the cycle and the heating strategy.
- Surface Quality according to the standards of the Aeronautic Industry.
- CTE strategy for dissimilar materials application.

The demonstrator shall comply with project targets in terms of structural complexity as described across this document. For bugdgeting purposes, a medium/small structure is to be considered. Topic Manager intends to use the results of this project for a bench-marking with the Outer Wing Box LRI running project.
The Topic Manager preferred proposal for the demonstrator is an aircraft door in order to maintain compliance with the above drivers. Main characteristics for the demonstrator shall be as follows. A picture is attached as a illustrative example:

- Main dimension up to 1.500 mm.
- Complex structural concept including: skin (wet surface), reinforcement external frame, longitudinal stringers and circumferencial frames, with a high integration dregree.
- Able to carry fuselaje shear loads and to withstand cabin pressure.
- Damage tolerant.
- Ability for systems high integration.
- Final deformed geometry monitoring and control.



Demonstrator Concept

a) Technological streams

The main technological challenges are as follows:

- Design-To-Cost basic approach.
- Design focused on maximum structural and systems integration.
- Revised Stress Analysis Methods for the materials to be used.
- Cost Efficiency in Tooling.

- Traditional issues fixing: spring-back effects for the final composite structure, NDT methods.

In addition, the main technological streams to be investigated are as follows:

AREA 1. DESIGN & ANALYSIS

- Design Methods "Low cost manufacturing oriented".
- Standardized analysis tools that can handle complex three-dimensional geometry and monitoring & control the inter-laminar stresses (peeling, unfolding, etc.).
- Optimised design processes supporting high integration (structure - systems) facilitating manufacturing, and low cost production.
- Robust design concept avoiding traditional composite manufacturing issues (delaminations, spring-back).
- Life cycle cost model.

AREA 2. MATERIALS AND PROCESS

- Cost-Oriented Tooling design solutions.
- Efficient processes (pre-forming and cycle injection-curing).
- Liquid Resin Infusion (LRI).
- NDI Efficient methods.

b) Goals

By means of a complex composite demonstrator for ground testing reaching TLR 6, the following goals shall be expected:

- Reduction of composite design and certification costs (including testing) of about 30% for the primary structure by means of standardization and KBE concepts.
- Reduction of structural weight of about 20% respect to metallic reference wing box weight by means of:
  - One Shot Concepts.
  - Reduction of about 95% of fasteners.
- Reduction of composite production costs of about 20% for the primary structure by means of:
  - OoA process.
  - Reduction of labour effort and labour errors.
  - Reduction of energy consumption during production.
  - Reduction of required raw material reducing the waste.
  - Reduction of about 95% of fasteners.
- Reduction of NRC costs of about 20% by means of:
  - Using innovative low cost tooling techniques (up to 40% of reduction in the tooling cost).

c) Tasks

The activities to be performed are divided in the tasks listed in the following table:

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T1	Demonstrator Design Requirement focused to final demonstrator selection to show the evidences which justify the choice for all requirements compliance.	T0+02
T2	Demonstrator Design and Analysis, centred into the high integration goal and design-to cost concept.	T0+08

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T3	Feasibility Design Review.	T0+02
T4	Preliminary Design Review.	T0+04
T5	Critical Design Review.	T0+06
T6	Manufacturing Process and Tooling Design throguh expected innovative concepts and technologies focused on cost reduction, maintaining aerospace class structural performance.	T0+06
T7	Test Plan through a pyramide test strategy to validate the proposed design concepts and technologies approach.	T0+06
T8	Tooling Manufacturing & Try-Out, according to the desing guidelines and materials & processes selected.	T0+12
T9	Demonstrator manufacturing according to acceptability criteria showing evidence of different technology targets.	T0+16
T10	Tests Execution, according to Test Plan to show substantiation with critical stress analysis allowables.	T0+17
T11	Industrialisation Assessment to feed research carried out based on main goals in comparison with equivalent manufacturing on thermoset material and correspondent process (bench marking with running ADS ITD comparative projects).	T0+18

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type	Due Date
D1	Demonstrator Selection	Document	T0+02
D2	Conceptual and Detailed Design and Analysis	CATIA Mod., FEM & Doc.	T0+04
D3	Manufacturing Process Approach	Hardware & Doc.	T0+08
D4	Tooling Design & Manufacturing	Hardware & Doc.	T0+10
D5	Demonstrator Manufacturing	Hardware & Doc.	T0+16
D6	Structure Verification	Document	T0+18
D7	Industrialisation Analysis	Document	T0+18

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

Management on R&T Level:

- Competence in management of complex projects of research and manufacturing technologies.
- Proven experience in international R&T projects cooperating with industrial partners, institutions, technology centres, universities.
- Proven experience in collaborating with reference aeronautical companies with industrial air vehicle developments.
- Experience and skills learnt from projects focused on similar tasks.
- Quality and risk management capabilities demonstrated through applications on

international R&T projects and/or industrial environment.
- Experience with TRL reviews or equivalent technology readiness assessment techniques in research and manufacturing projects for aeronautical industry.

Field of Expertise:
- International proven experience leading aircraft development projects combined with wide expertise in management of research work packages.
- Proven competence in leading aircraft project drawings, structural analysis and composite materials damage tolerance.
- Strong capabilities in numerical optimization.
- Proven aircrafts manufacturing experience in substructures.
- Proven experience in non-destructive inspections.
- Proven experience in experimental testing: in particular impact threat, residual strength and fatigue testing from subcomponents to full scale test article.
- QM Management**:** Setting up inspection schemes.
- Proven experience in: RTM, processing liquid resin infusion, vacuum assisted or similar process.
- Proven experience in design and manufacturing of manufacturing tooling for structures in different materials. Capacity to repair or modify "in-shop" the prototype manufacturing tooling for components due to manufacturing deviations. Experience and know-how with tooling for OoA technologies.
- Proven experience in the use of design, analysis and configuration management tools of the aeronautical industry (i.e. CATIA v5, MSC NASTRAN, etc.).

Manufacturing, Testing & Tooling including facilities:
- Capacity to repair "in-shop" components due to manufacturing deviations.
- Technologies for composite manufacturing with OoA processes.
- Tooling design and manufacturing for composite components.
- Suitable machines for hot-forming, injection and curing for the representative demonstrator.
- Qualified NDI.

Track record:
- Approved supplier for composite structures for aeronautical industry.

Approvals:
- Quality System international standards (i.e. EN 9100 / ISO 9001).
- Special Processes Qualification (NADCAP).

VIII. Integrated electronics for actuator data and power management for Morphing Leading Edge activities

Type of action (RIA or IA)	IA		
Programme Area	AIRFRAME		
Joint Technical Programme (JTP) Ref.	WP B-3.2		
Indicative Funding Topic Value (in k€)	450		
Topic Leader	Fraunhofer	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[46]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-AIR-02-41	**Integrated electronics for actuator data and power management for Morphing Leading Edge activities**
Short description	
This topic foresees a unitary device made of two complementary sub-units for installation of suitable EMA as driving elements of the morphing leading edge. The device must be able to control the EMA as well as the power supply requested.	

[46] The start date corresponds to actual start date with all legal documents in place.

1. Background

Active Flow control (AFC) is one approach to minimize the environmental impact of air transportation due to the goals defined in the ACARE 2050 agenda. Morphing structures are a promising solution for noise and drag reduction in future aircraft. They are intended to replace or supplement current aircraft high lift devices, which today typically have the disadvantage of gaps in deployed position. These gaps are unintendedly sources of noise radiation and aerodynamic drag. Morphing structures replace these devices by a gapless solution based on skin deformation of the wing. In WP B-1.4 of the Airframe ITD a morphing leading edge replacing conventional leading edge high lift devices, like for instance slats, will be under investigation. For the design of a morphing structure it is important to define the desired shape, keeping in mind material limitations, which represent a limitation for the possible shapes that the morphing structure can assume. In addition, the morphing structure needs to be equipped with a reliable actuator in order to achieve the desired shape. To mature new large scale morphing structures towards large-scale ground tests and even flight tests, there is a need of a power supply unit that is also able to smart control the actuator system. Due to the need of feed-back control of each individual actuator and due to the need to control a large amount of actuators in one specific application scenario (Morphing Leading Edge), there is a need for a higher-order control structures. These control levels are necessary to implement application specific control algorithms in the power supply unit and consequently maximize the benefit of the morphing system.

2. Scope of work

This topic foresees a unitary device made of two complementary sub-units: one for controlling the EMA actuators for driving the morphing Leading Edge; the other capable of managing the power necessary for the activation of the system. Both sub-units are strictly connected and shall be able to work in an integrated way.
The first objective of this topic is the development of a drive and control system for EMA actuators of the Morphing Leading Edge. The main challenge is represented by the development of smart control architecture to reduce the amount of data that is transferred through the control system. A specific data amount is necessary due to the fact that the actuators are controlled, monitored and attached to a structure that is equipped with additional sensors for load monitoring and shape reconstruction. These different levels of available data and control loops require smart data architecture. For this purpose, the system will be divided into several control levels, each handling level-specific data.
The second objective deals with the power management of the actuators. The dedicated unit must be able to handle the energy requested in order to control the power supply for actuators. This also includes the monitoring of the drive stage of the actuation. The applicant shall design and manufacture a platform that will be used to implement the MuLeCoCo (Multi Level Control Concept) in order to test and evaluate the control strategy and data reduction approach, along with the power management. The system shall also be suitable for testing at small scale, let's say for assessing feasibility and main features on a smaller scale, as well as for later implementation in the real environment at larger or full scale.
The overall objective of the topic is the design of a smart control strategy that can handle the specifics necessary for driving and monitor the actuators of the morphing system. The implementation shall be done with a control approach which is capable to be used in small scale tests, as well as GBD tests. For the control of actuators in morphing structures, several control levels are necessary. This project deals mainly with the level to control multiple actuators at one local concentrated application area. The Topic Manager will specify an interface to higher control levels at

the beginning of the project. An interface to the actuators will be specified also at the beginning of the project in discussion with the actuator developers. Within the control strategy a large amount of data has to be handled. Appropriate solutions for data acquisition and management have to be considered and implemented.
The applicant shall design and manufacture both, a hardware platform and the software based implementation of an appropriate control concept in order to test and evaluate the control and data handling approach. The system shall also be capable to be used for control and test of actuators e.g. in a small or large-scale ground based demonstrator (GBD). Therefore, advanced monitoring functionalities shall be implemented and all parameters accessible via common data acquisition systems. An open sensor interface shall provide also the option to extend the system for aerodynamic control algorithms.
The outcome of the topic is the development, the manufacturing and the test of the integrated control device for actuators and sub-units in a morphing structure. The tests will proof compliancy of this device to the requirements to enable the use in final tests of the GBD (WT/T). All interfaces (e.g. to sensors or drive electronics) will be specified in discussion with the Topic Manager at the beginning of the project.
The required activities shall include the following tasks:

1. Development of a hardware platform for a actuator drive and control concept for morphing structures
2. Definition of specifications and interfaces for sensors and driving units of the actuator system
3. Development of control algorithms that are adaptable and verifiable by common simulation tools
4. Development of software that is capable to monitor system parameters
5. Implementation of an advanced monitoring interface
6. Implementation of modular software with different control algorithms
7. Manufacturing, Integration and Test of the whole platform.

Basic Requirements for the control system are as follows:

- Compact standalone control device with electronics and software
- Final device has to be suitable for use in aircraft scale GBD hardware
- Device shall be protected against dust and water (minimum IP65) or shall be integrated in a Smart Actuator drive system capable to be used for WT/T and operation in harsh environmental conditions (aircraft specific environment)
- Advanced remote monitoring functionalities.

It is proposed to structure the technical activities by using the following WBS:

WP1 - Specification and interface definition
The main objective of this work package is the development of the specifications of the control system for morphing LE actuators. The Topic Manager providing the following information will support the applicant:

- Specifications on targeted or available actuators

- Specifications and details on space allocation
- Specification of the interface to higher control levels

As early information, it is expected a power consumption of around 100 W for distributed actuation but this will be fixed at the beginning of the project.

WP2 - Development of system structure and control algorithms

Work package 2 deals with the definition and development of the whole control system and its sub-systems. This will include the manufacture or procurement of:

- Smart control system (consisting of: driving module, control unit, sensor data acquisition unit and communication unit) and a suitable housing solution
- Actuator connection interfaces
- Higher control level interfaces

The definition of the specific system conditions is based on the specifications defined in WP1.

WP3 - Development of a demonstrator and manufacturing (hardware & software)

Work package 3 deals with the manufacturing of the demonstrator system for LE morphing control including its sub-systems. This will include the manufacture or procurement of all components of the system and pretesting of the system.

WP4 - Lab testing with actuators

The final drive and control hardware developed within WP2 shall be tested in a relevant environment. Main objective is the validation of the functionality for the given system specifications as outcome of WP1 as well as the proof of functionality with scale one actuators. The Topic Manager will provide full-scale actuators.

3. Major deliverables/ Milestones and schedule (estimate)

Major Deliverables and Milestones are summarized in the tables below. Depending on the work description, this list can be expanded where necessary.

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
Del.1	**System concept: Conditions of Supply, Implementation and Delivery Plan**	**Report**	**T0+3**
Del.2	**Interface definitions**	**Report**	**T0+10**
Del.3	**1st Annual Review**	**Report**	**T0+12**
Del.4	**Implementation specification sheet**	**Report**	**T0+12**
Del.5	**2nd Annual Review**	Report	**T0+24**
Del.6	**Delivery of the hardware / software for test**	Hardware	**T0+30**
Del.7	**Test and characterization report**	Report	**T0+35**
Del.8	**Final Test and Final Report / Final Meeting**	**Report**	**T0+36**

Milestones		
Ref. No.	***Title - Description***	***Due Date***
M1	**Preliminary Specification**	T0+6
M2	**Preliminary Hardware/Software design review**	T0+18
M3	**Critical Hardware/Software design review**	T0+24
M4	**Final Hardware delivery**	T0+30
M5	**Final Hardware test finished and reported**	T0+36

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

The applicant shall demonstrate expertise in the field of:

- Electronic system design and integration
- Software development and test
- Control of electromechanical actuators.

The applicant shall demonstrate also capabilities to:

- manufacture the hardware of the system
- integrate and verify the simulated control algorithms into the target hardware
- perform tests to proof compliancy of the system to the requirements.

IX. Layup tools for net-shape AFP-manufacturing of geometrically complex helicopter sideshell sandwich-panels

Type of action (RIA or IA)	IA		
Programme Area	AIRFRAME		
Joint Technical Programme (JTP) Ref.	WP B-3.3.10		
Indicative Funding Topic Value (in k€)	400		
Topic Leader	Fraunhofer	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	16	**Indicative Start Date**[47]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-AIR-02-42	**Layup tools for net-shape AFP-manufacturing of geometrically complex helicopter sideshell sandwich-panels**
Short description	
Development and manufacturing of layup tools that enable the manufacturing of airframe demonstrators (four sideshell panels, surface areas between 3 m² and 5 m², geometrically complex including double curved areas and sandwich structures) with Automated Fiber Placement technology.	

[47] The start date corresponds to actual start date with all legal documents in place.

1. Background

Due to the excellent performance to weight ratio, composite materials are essential in order to address the goals defined within the ACARE 2050 agenda, like weight reduction, fuel savings or environmental footprint. Helicopter airframe structures are regarded as one of the most complex parts in commercial aerospace applications because of the high structural and system demands. The parts are still manufactured in hand layup processes, resulting in a low productivity, high material costs and limitations regarding a load-path adapted design.
In WP B-3.3.10 of Airframe ITD, the potential of the Automated Fiber Placement (AFP) technology in this application field is to be investigated for manufacturing sideshell structures of the LifeRCraft demonstrator. The AFP process is one of the most promising technologies for highly automated CFRP part manufacturing. The robot based layup system offers the opportunity to realize complex geometries in or near net-shape. When a multi-tow layup head is applied, scrap can be reduced to a minimum, which has positive impacts on cost per part and life cycle analysis. Even though the AFP technology is already being applied in serial production of monolithic parts, there is still a significant weight and cost optimization potential, especially for complex structures including sandwich areas.
The airframe of the high-speed helicopter is divided into several shell structures. Four of these shells will be manufactured using AFP technology. For each considered shell a separate layup tool is required, since the shape of the tool surface corresponds to the desired part geometry in this net-shape layup process.

2. Scope of work

The aim of this CfP is to develop and provide all required tools to enable the Automated Fiber Placement manufacturing of four different helicopter sideshell panels in WP B-3.3.10. The focused shell panels have surface area sizes of around 3 - 5 m², with a max. length of 2 m. The parts have a complex geometry with double curved areas and local sandwich structures. The topic is divided into three phases that correspond to the proposed work plan.

In the first phase, the applicant is required to develop a suitable tooling concept for each of the considered parts with respect to the manufacturing, curing and assembly strategies defined by the Topic Manager. Besides the previously mentioned layup process, this also includes the necessary post-layup processing steps to enable part curing. Compared to state of the art AFP part production of monolithic parts, the focused side shells involve sandwich structures which require the development of a suitable process chain. This will be done in close collaboration with the Topic Manager. For a direct layup on the cores, in order to assure a highly reproducible, accurate positioning of the cores on the layup tooling, positioning patterns are necessary. For a separate layup process, resulting in various sub-preforms, assembly tools will be needed to enable a controlled fusion process before curing. Furthermore, transfer tools to assist the removal of the preform(s) from the layup tool and of the final preform into the curing tool are required. As a result of this phase, the applicant needs to provide a detailed tooling concept for each part under examination including layup and all required auxiliary tools. These will be discussed in the tooling concept review which concludes this phase.

In the second phase, the applicant needs to perform preliminary design and subsequently detailed design of all required layup and auxiliary tools which are necessary for the realization of the overall

tooling concept developed in the prior phase. This requires a critical assessment of all technical challenges and boundary conditions that will be provided by the Topic Manager in terms of design requirements and corresponding guidelines along with the final part design of the shell panel. As Airframe ITD WP B-3.3.10 aims for geometrically complex parts that also involve sandwich structures, the desired layup tools have to fulfill certain requirements beyond the state of art in order to enable high accuracy and quality throughout the manufacturing process. The tooling material and surface condition has to be carefully selected, as it is one key factor for the layup behavior of the material, especially when first ply layup directly on the tool is considered. Boundary conditions like collision-free accessibility for all desired layup directions have to be taken into account. The kinematic phenomena of the positioning system in combination with the tool carrier have to be carefully addressed, with a special focus on unwanted inertia effects on the layup accuracy. Furthermore, possible shrinkage and warpage of the part during curing has to be critically analysed in layup tool design. For this purpose, preliminary experimental or simulative studies have to be performed in cooperation with the Topic Manager. Based on the outcome, an adapted preform design has to be developed to compensate these effects. This preform design then is the basis for the layup tool. To be able to perform machining operations post consolidation, trim and docking excess has to be added to the engineering edge of part. Because of the variety of factors and boundary conditions, iterative loops including feasibility trials might be necessary throughout the design phase. All layup tools have to be compatible to the mounting systems of Topic Manager's fiber placement work-cell. To enable high layup accuracy, probing will be used in order to compensate deviations between the simulated tool mounting, which is basis for the course definition and toolpath generation, and the actual mount.
For each focused part, a preliminary design review will be held in which the applicant presents a preliminary design of the layup tool. Based on the Topic Manager's feedback, the applicant subsequently develops the final tooling design, which is then verified in the critical design review. In order to optimize the design process throughout the project and to enable a quicker tool delivery, this process is performed iteratively for each of the four tools (see deliverables and milestones, section 3).

The third phase focusses on the actual tool fabrication by the applicant consistent with the results of the critical design review. The final tools have to be delivered as four sets of layup tool and corresponding auxiliary tools to Topic Manager's workshop facility located in south of Germany accordingly to the schedule. To avoid unwanted geometrical deviations from the desired shape, a quality check is to be performed on site. The layup tools shall be measured by the manufacturer using a 3D-scanning device. Results have to be compared with the provided CAD data, deviations shall be indicated and compared to the requirements defined in WP1.

It is proposed to structure the technical activities by using the following WBS:

WP1 – Tooling concept development

- Development of a part-specific tooling concept that enables AFP-based production of four Helicopter airframe sideshell panels

WP2 – Layup and auxiliary tool design

- Design of an individual layup tool for each part according to requirements and design guidelines defined by the Topic Manager
- Requirements for the layup tool design include:

- Geometrical coincidence of the layup area with the adapted preform geometry, which needs to be developed by the applicant based on the original part to compensate curing effects like shrinkage and warpage
  - Compatibility of the tooling to Topic Manager's work-cell mounting systems
  - Surface quality according to the requirements
  - Collision-free fiber placement head accessibility of the whole tool surface in every desired fiber direction
  - Lightweight construction to minimize inertia effects while positioner movement
- Design of all required auxiliary tools which are required to perform the entire process chain starting with layup, including core positioning to the transfer of the preform to the curing tool

WP3 – Tool fabrication, delivery and quality check

- Fabrication of all layup and auxiliary tools
- Delivery of the tools to Topic Manager located in south of Germany
- On site quality check using 3D-scan methods

3. Major deliverables/ Milestones and schedule (estimate)

Major deliverables and milestones are summarized in the tables below. Depending on the work description, this list can be expanded where necessary.

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
Del.1	**Tooling concept for all sideshells**	**R**	**T0+2**
Del.2.1	**Final CAD model layup tool rear side shell right half**	**OTHER**	**T0+4**
Del.3.1	**Layup and auxiliary tools rear side shell right half**	**DEM**	**T0+4**
Del.2.2	**Final CAD model layup tool rear side shell left half**	**OTHER**	**T0+8**
Del.3.2	**Layup and auxiliary tools rear side shell left half**	**DEM**	**T0+8**
Del.2.3	**Final CAD model layup tool rear intermediate shell right half**	**OTHER**	**T0+12**
Del. 3.3	**Layup and auxiliary tools rear intermediate shell right half**	**DEM**	**T0+12**
Del. 2.4	**Final CAD model layup tool rear intermediate shell left half**	**OTHER**	**T0+14**
Del. 3.4	**Layup and auxiliary tools rear intermediate shell left half**	**DEM**	**T0+14**
Del. 4	**Final Report**	**R**	**T0+16**

Milestones		
Ref. No.	***Title - Description***	***Due Date***
M1	**Tooling concept review**	**T0+2**
M2.1	**Preliminary Design Review (PDR) layup tool rear side shell right half**	**T0+2**
M2.2	**PDR layup tool rear side shell left half**	**T0+5**
M2.3	**PDR layup tool rear intermediate shell right half**	**T0+9**
M2.4	**PDR layup tool rear intermediate shell left half**	**T0+10**

Milestones		
Ref. No.	***Title - Description***	***Due Date***
M3.1	**Critical Design Review (CDR): Approved Tooling Design layup tool rear side shell right half**	**T0+3**
M3.2	**CDR layup tool rear side shell left half**	**T0+6**
M3.3	**CDR layup tool rear intermediate shell right half**	**T0+10**
M3.4	**CDR layup tool rear intermediate shell left half**	**T0+12**
M4	**Final Meeting**	**T0+16**

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

- Experience in tooling concept development for CFRP process chains is mandatory
- Experience in tooling design for CFRP parts with aerospace background is mandatory
- Experience in manufacturing tool and quality assurance manufacturing is mandatory
- Availability of machining facilities to manufacture all shell parts with the specified dimensions as one part is mandatory
- Availability of 3D-scanning equipment to perform quality check of tool dimensions is mandatory

X. Low cost optical wave guides for damage detection including analysis and aircraft data transfer related to aircraft functional needs with self-testing connection

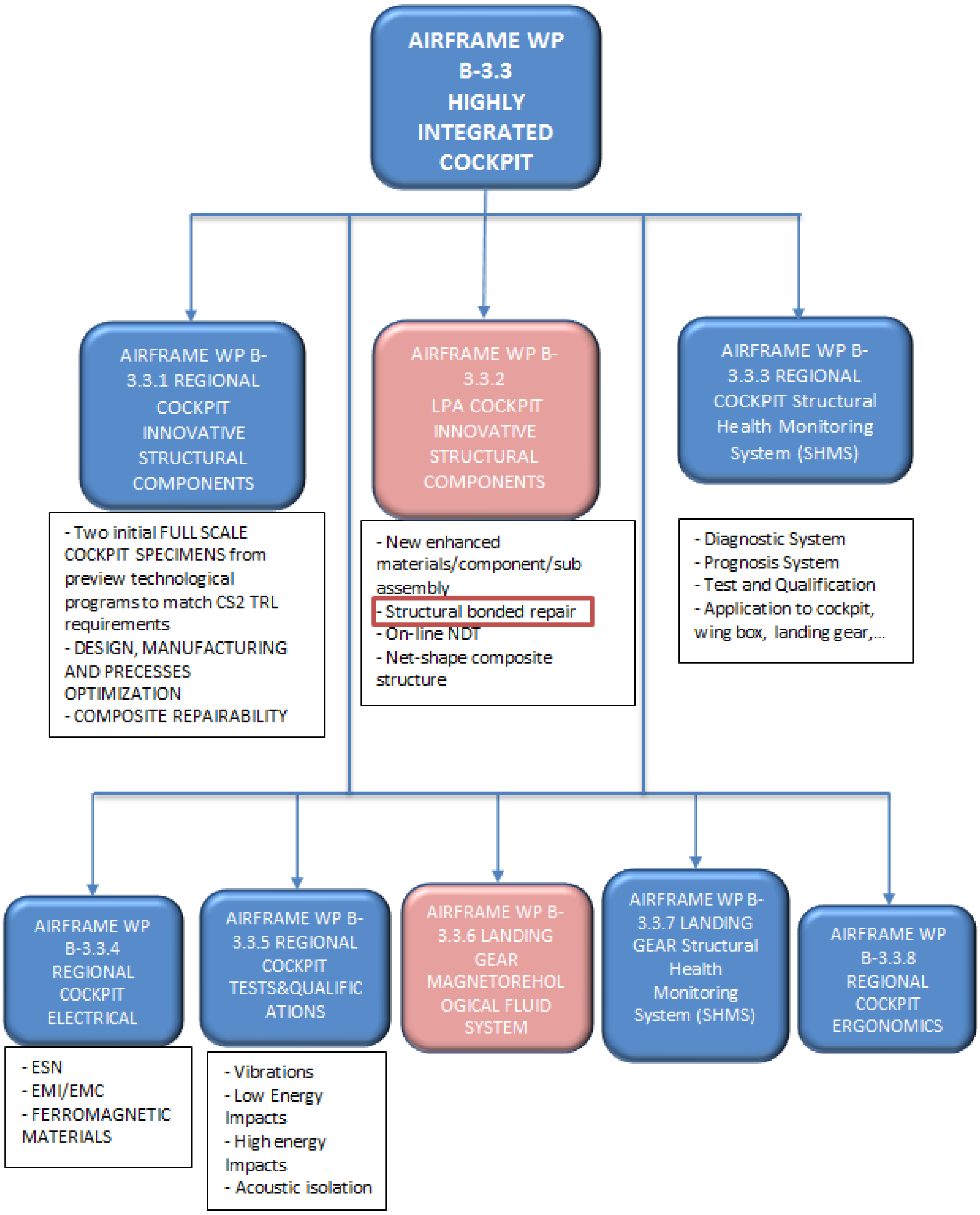
Type of action (RIA or IA)	RIA		
Programme Area	AIRFRAME		
Joint Technical Programme (JTP) Ref.	WP B-3.3.2		
Indicative Funding Topic Value (in k€)	850		
Topic Leader	Airbus	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[48]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-AIR-02-43	**Low cost optical wave guides for damage detection including analysis and aircraft data transfer related to aircraft functional needs with self-testing connection**
Short description	
The project will develop, design and realize a network of optical wave guide prototype with different functionalities such as damage detection and diagnosis (delamination- corrosion - cracking) and in specific areas of the aircraft sustaining data transfer for cabin needs and/or from known Fibber Bragg Grating or Brillouin sensing technologies. It must be self-sourcing and all the connections must have the capability of self-testing the working condition optimization. The industrialization must be automatised and Eco Efficient in production and in service repair conditions.	

[48] 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 planned activities will be performed in the frame of the “On-line NDT” project, to facilitate implementation of “Online NDI/Process Monitoring” in composite manufacturing processes and in aircraft maintenance inspection. The project target is to build a Network of optical wave guides with different functionalities (see figure 1), with self testing connections, compatible with aircraft system standards and wireless questionning capability. All will be managed by one system integrating all type of sensors and be self sourcing.

Figure 1 – Illustration of typical Network distribution

The network made of low cost optical wave guides must have typical functionalities such as damage detection and diagnosis capabilities for delamination - corrosion - cracking - loading measurement. On top specific areas of the Network must support data transfer for cabin entertainment. The network will be made of optical fiber sensing based on Fibre Bragg Grating and Brillouin analysis, plus a new optical wave guide to be developed for delamination detection on large surfaces.

In comparison with classical monitoring technologies, optical fiber sensing technologies have demonstrated industrial interest and high level of sensibililty, reducing weight when it is used for data transfer as on A380 and A350 aircrafts, not sensible to EMI , and offering other functionalities such as loading, temperature and pressure measurements.

Those technologies have been evaluated on specific aircraft configurations, delivering data aligned with expected results. Feedbacks from potential end-users identify that some gaps must be solved for an industrial implementation on aircraft, such as: light transfer optimization automatic diagnosis, bonding or assembly technology, transceiver architecture and miniaturized design. The possibility to detect delamination with known optical fiber sensing is still missing.

Identified gaps described hereunder need to be addressed by the project:
First, light transfer at optical fiber connections is critical, a testing process is implemented inducing a minimum of 2h per system control. Topic Manager expect an industrialization optimized by an innovation of an automatic self testing integrated into the connection devices.
Secondly, Fibre Bragg Grating and Brillouin sensing capabilities are investigated. Their field of applications are identified in the aeronautical context. In order to facilitate their integration into aircraft structure, it is needed to develop an optimized set up of those sensing and identify the less costly industrial integration of different sensors, self sourcing and self testing connections. All must respectaeronautical specifications for manufacturing and aircraft maintenance contexts.
Third, the above mentionned technologies are not optimized to detect delamination on large surfaces that could be exposed to impact during manufacturing, assemblies, flight and aircraft maintenance.

The detecting media must give a 2 dimensions localization. Therefore the project will develop an innovative low cost sensing technology specific for delamination detection, targeting coverage of large surface of the aircraft of about 10 square meter

The detecting sensor will be not inserted into the composite lay up, but on top and will be covered by final paints customized to airlines specifications. It must be easily replaced in maintenance by adapted automatic devices.

The based material already developed for light transfer for Space application, is made of a mixture of Solid material mixt with Gel technology, commonly named SolGel material. The project will develop the sensing capability for detection and identify localization of the delamination at least on 2 dimensions with a spatial resolution of 2mm.

The lay up process of the sensor on the aircraft surface must be integrated and adaptable to different industrial context such as: component manufacturing, assembly lines, and finaly to aircraft operations in maintenance.

In Clean Sky 2 context, the final system will be realized by an automatic machine that could be implemented on automatisms developed specifiquely for a center fuselage section part of a Demonstrators in ITD LPA Platform 2.

The developments must be oriented to sustain possible self-sourcing, wireless questionning and data transfer based on aeronautical system standards that will be defined by the Topic Manager.

2. Scope of work

The project shall develop a new sensor for delamination detection based on SolGel technology. In addition, a network of optical wave guide prototype shall be designed and realised supporting different functionalities such as damage detection and diagnosis (about delamination - corrosion - cracking) by integrating FBG- Brillouin- SolGel technologies. This Network will sustain data transfer for cabin needs. The network must be self-sourcing and all the connections must have the capability of self-testing the working condition optimization.

The industrialization aspects must be oriented to automatic process specific for large structure aircraft and be eco efficient. The interfaces requirements will be delivered by the Topic Manager.

To validate working conditions, and demonstrate compliance with aircraft design requirements defined by the Topic Manager, a Network prototype must be implemented on a curved stiffened panel of 2m by 2m with demonstration of delamination detectability. Delaminations will be induced for detectability demonstration.

The project will be subdived in following tasks:

Tasks		
Ref. No.		***Due Date***
Task 1 – Configuration definitions	Targeting an optimized set up of the sensing technologies all around the aircraft and identifying integration constraints, this task will identify and define specific requirements from the industrial contexts (Structural and Electrical Systems) and automatic process specifications, all with Topic Manager inputs. It will be background of the Network concept and of the final evaluation.	T0+3

Tasks		
Ref. No.		***Due Date***
Task 2 - Delamination detector	Design and develop a delamination detection and localization optical sensor wave guide made with SolGel technology for large aircraft surface with demonstration of capability.	T0+12
Task 3 - Self Testing connections	Design and development of self testing connection devices for optical fiber sensing technologies.	T0+12
Task 4 - Optical Network	Design and development of the Network prototype including Optical fiber (FBG-Brillouin) and delamination sensing technology developed in Task 2, with new connecting devices developed in Task 3.	T0+21
Task 5 - Evaluation & Validation	Integration and evaluation of the prototype on a demonstrator in laboratory environment (applicant and Topic Manager) – Tests and validation of detection capabilities (delamination- loading- corrosion) and functionalities (data transfer- selftesting) will be defined and realized with Topic Manager contribution.	T0+34

3. Schedule for Major Deliverables/Milestones (Estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
1.1	List of the specific requirements from the industrial context (Structural and Systems) and automatisation specification inputs	Report	T0+3
2.1	Sensing system for delamination detection and localization	Prototype	T0+12
2.2	Sensing system for delamination detection and localization, evaluation on basic cases	Report	T0+15
3.1	Design and development of self testing connection devices for optical fiber sensing technologies	Prototype	T0+12
3.2	Self testing connections, demonstration of effective working condition within a basic Optical fiber sensing set up	Report	T0+15
4.1	Network concept	Report	T0+20
4.2	Decision gate for Go – NoGo to task 5, with the Topic Manager	Milestone-report	T0+21
5.1	Curved composite structure demonstrator for future network implementation	Curved composite demonstartor (2x2m)	T0+24
5.2	Evaluation of the complete Network prototype including developments from Task 1 to Task 4, demonstrating working conditions and 100% efficiency of light transfer and sensing efficicency from the whole network- end to end	Report	T0+34

Activity *months →*	+3	+6	+9	+12	+15	+18	+21	+24	+27	+30	+33	+36
Task 1 Definition of Network requirements	D											
Task 2 Delamination sensor				D	D							
Task 3 Development of self testing connectors				D	D							
Task 4 Network definition							D M					
Task 5 Working Network								D				D

***D = Deliverable & M = Milestone**

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

The applicant(s) shall have:

- Experiences in the different disciplines of the optical sensing technologies including specific automated measurement systems;
- Experiences in the field of aircraft production and assembly including all main aspects of production processes and industrialization constraints;
- Demonstrated capability to design and to produce connecting devices with integration of new optical elements;
- Experiences in SolGel technologies and material supply capabilities for minimum 0,5x0,5 m sheet of material;
- Experience in data processing in optical fiber sensing technologies, such as FBG and Brillouin;
- Experience and related industrial capabilities in design and production of miniaturized optoelectronic devices, such as transcievers, bolometers, interrogating devices;
- Experience in interdisciplinary research and development team/consortium management;
- Knowledge in wireless technologies applicable to optical wave guide systems.

XI. Adjustable high loaded rod

Type of action (RIA or IA)	IA		
Programme Area	Airframe		
Joint Technical Programme (JTP) Ref.	B-3.3.2		
Indicative Funding Topic Value (in k€)	400		
Topic Leader	Airbus	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[49]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-AIR-02-44	**Adjustable high loaded rod**
Short description	
High loaded rods are used in specific area for: space allocation, specific load introduction, etc. Its installation in integration phase can be complicated due to overall tolerance management & design specification. The aim of the study is to propose new solutions which can allow length & hinge angle rigging pending of situation.	

[49] 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 work-breakdown structure hereunder.

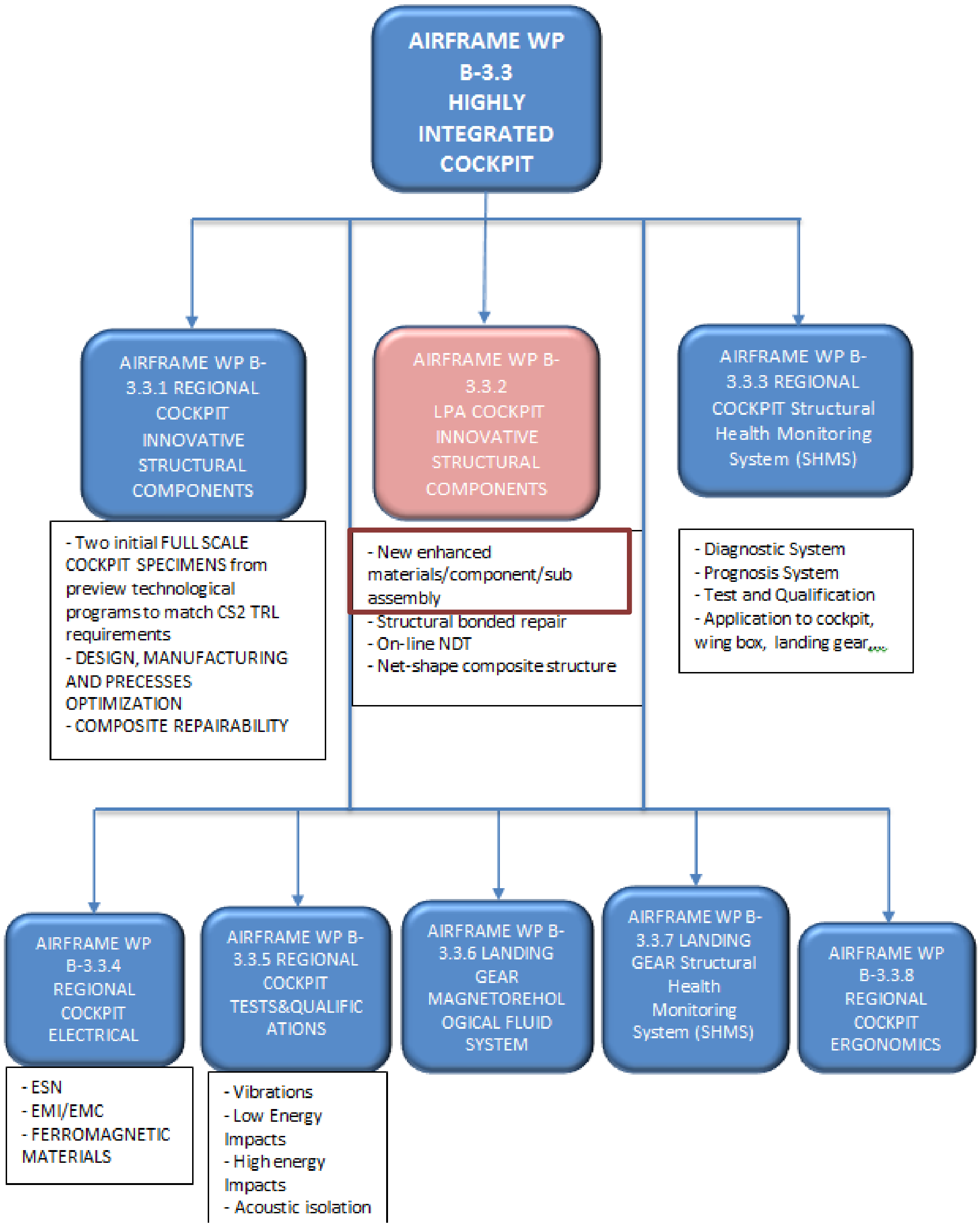


Figure 9: WP B-3.3 WBS

Current structral rods used for aircraft application do not allow any flexibility for their installation in integration phase. Indeed, their assembly is hyperstatic. Therefore, some adjustments are necessary

to compensate the aircraft assembly tolerances, as the drilling of their axis holes in accordance with a measurement preliminary performed on the assembly line.
This concept is time consuming and is not compatible with a high rate of production of aircrafts.
In order to simplify their installation and to reduce the time of assembly, it is proposed to develop a high loaded adjustable rod. The main objective is to develop a smart and robust solution compatible with a high rate of aircrafts production while respecting the aircraft environment constraints.

2. Scope of work

In the framework of the study of the innovative Body Landing Gear which is developed for the next generation of lower center fuselage, 3 rods are considered to attach each Landing Gear fitting to the fuselage. The objective of this study is to develop high loaded adjustable rods up to TRL4 (Route to industrialisation) to ensure these attachments.
By “Route to industrialisation“, it is meant that the TRL4 level is the transition between a technology validation and the demonstration of its feasibility at industrial scale. At this stage, a robust roadmap of the tasks to complete up to TRL6 has to be provided. In addition, technical and project risks have to be clearly identified, and the associated mitigation plan has to be defined. The feasibility of implementation in industrial scale has not to be secured in this CfP.
The main features of these attachments are presented hereafter:

- The level of tension / compression loads transfered in each rod is around 800 KN (80T).
- The theoretical axis to axis distance depends of the rod: the value to consider is 800mm for the shortest rod and 1350mm for the longest rod.
- The adjustment range to consider for each rod is at least 10mm (+/-5mm around the theoretical axis to axis distance).
- The adjustment accuracy to consider for each rod is at least 0,1mm.
- Each rod can be attached to male or female fittings.
- Attachments axis of each rod are not aligned (unequal angular position around rod longitudinal axis). The angle of misalignment depends of the rod. The maximal value to consider is 90°.
- The thickness of the male fittings is not the same for each rod. The value to consider is 20mm for the thinnest fitting and 40mm for the thickest one.

The applicant must demonstrate that its solution is compatible with the design & stress requirements listed previously by using either simulation, or mechanical tests, or the two combined methods.
No material is imposed for the rods, but the applicant must propose high performance aeronautical material(s) in order to minimize as much as possible the weight of the rods. Nevertheless, the selection of the material(s) will be performed with the agreement of the Topic Manager, supported by material and process departement.
The applicant must demonstrate that its solution is robust and can be applied to high production rate programs (over 70 aircrafts per month). In this frame, an assessment of the industrial manufacturing process must be performed and the associated serial recurrent cost (RC) of the solution needs to be mastered. This RC will be compared to a conventional solution during the study.
A full scale prototype of one of the 3 rods must be manufactured by the applicant and an installation trial must be performed on simulated attachment fittings. The test bench (to support the simulated attachment fittings) must also be manufactured by the applicant.

A list of tasks to be performed is here provided:

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T 1	**Management and coordination**	T0 + 24
T 2	**Detailed planning** for Engineering and Manufacturing activities with risks associated	T0 + 3
T 3	**Concepts down selection**	T0 + 10
T 4	**Concept validation and preliminary design & stress study**, including tolerance studies and a 3D Digital Mock-Up	T0 + 16
T 5	**Preliminary assessment of the industrial manufacturing process**	T0 + 16
T 6	**Mechanical tests**	T0 + 20
T 7	**Design refinement**	T0 + 24
T 8	**Manufacture of the demonstrator & installation trial**	T0 + 24
T 9	**Assessment of the industrial manufacturing process & associated RC**	T0 + 24
T 10	**Value and Risk analysis**	T0 + 24

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	T0 + 3
D 2	**TRL2 maturity**	Report	T0 + 10
D 3	**Preliminary design & stress dossier**, including tolerance studies and a Digital Mock-Up	Report CAT parts	T0 + 16
D 4	**TRL3 maturity**	Report	T0 + 16
D 5	**Mechanical tests report**	Report	T0 + 20
D 6	**Final design & stress dossier**, including tolerance studies and a Digital Mock-Up	Report, CAT parts	T0 + 24
D 7	**Trial report of the Full scale demonstrator**	Report, part	T0 + 24
D 8	**Industrial dossier**	Report	T0 + 24
D 9	**TRL4 maturity**	Report	T0 + 24

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M 1	TRL2 – Concepts down selection based on preliminary study	Technology review	T0 + 10M
M 2	TRL3 – Detailed solution validation	Technology review	T0 + 16M
M 3	TRL4 – Route to industrialisation	Technology review	T0 + 24M

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

Mandatory skills:

- Knowledge of aeronautical environment.
- Recognized skills in aircraft structural parts design & sizing.
- Recognized experience in manufacturing of structural parts for aeronautic.

Experience in design, sizing and manufacturing of structural rods for aircraft applications would be well appreciated.

Mandatory capability:

- CAD software: CATIA V5 and later.
- Numerical simulation software with DFEM approach (i.e. Patran/Nastran)
- Manufacturing facilities and equipment.

XII. Development and deployment of PLM Tools for A/C Ground Functional testing with Eco-design criteria

Type of action (RIA or IA)	RIA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	B-3.6		
Indicative Funding Topic Value (in k€)	400		
Topic Leader	Airbus D&S	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	18	**Indicative Start Date**[50]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-AIR-02-45	**Development and deployment of PLM Tools for A/C Ground Functional testing with Eco-design criteria**
Short description	
The objective of the Call is to develop digitalization of life cycle of Ground System Test based on Eco Design. These novel and advanced way to realise Ground Test, increases quality control and flexibility besides reducing manufacturing cost. All those advantages shall be confirmed using these new process and capabilities in demonstrators of AIR ITD.	

[50] The start date corresponds to actual start date with all legal documents in place.

1. Background

The framework of this topic is the Clean Sky 2 Airframe *Work Package 3.6: "New Materials and Manufacturing Technologies.* In particular this topic deals with on-ground testing technologies applicable to airframes which are directly linked to works done by the Topic Manager.
The objective of the Call is to develop process end to end for Ground Test from design office to manufacturing stages based on connection of several tools (corporate tools for Digital Mock-up) used during the life of cycle of aircraft functional tests. This novel and advanced way to perform Ground Test increases quality control, traceability and flexibility besides reducing manufacturing cost. All those advantages shall be confirmed using these new process and capabilities in demonstrators of AIR ITD.

During the previous decade Product Lifecycle Management (PLM) concept and tools were developed as new configuration systems. However they were only focused and applied on the product and its transformation, but not on the Functional Tests and eco criteria.
On one hand, with the purpose of preventing emissions, reducing waste and energy, this project is taking the step toward eco-efficient aerospace assembly processes. The following three elements, acting together, will be the main line to be followed:

- The set of parameters that impact in an eco-efficient aerospace assembly.
- The platform where the impact will be analyzed: PLM platform.
- The simulation in a 3D virtual environment where the assembly process will take place before they are implemented in a real environment (shop-floor).

On the other hand, development and consolidation of Functional Test PLM concepts, based on a concurrence of processes, methods, tools, networks, will allow optimizing and strengthening development process, industrialization and support, being the necessary base for new concurrence engineering in Functional Test.

2. Scope of work

The activities to be performed can be organized in two main activity lines, as follows:

Activity 1 - ECO-Efficient assembly processes
The scope here is to define which parameters are relevant when designing assembly processes to decide how they are impacted by efficiency in terms of energy and resources used.
An activity to find out the relevant parameters and how to measure and compare them vs current ways of developing assembly processes, will be carried out by the Topic manager. As a result of the previous activities, a report with functional and technical requirements will be the main input of the work to be performed by applicant.
The proposed way for developing the activities is in two phases.

- Phase one shall determine a first definition of the model and its prototype. As a result of the tests carried out from this first approximation, a deeper knowledge of the influence of the eco-efficient parameters shall be developed and as a consequence.
- The second phase of the project shall develop the final model.

The Topic manager will provide mostly the requirements, use cases and data needed for the analysis of an assembly to become more eco-efficient, while the applicant will cover the areas that are not

Topic Manager business core: the software development.

The following table summarizes the activities to be performed by the selected partner:

Activity 1 - Work Packages			
Title - Description		***Responsible***	***Due Date***
WP1 Model Definition	Model first estimation for development using first version of technical and functional requirements.)	Partner	T0+1
WP2 Model Validation	WP 2.1 Development of a first version of the model using PLM tools for validation of energy efficiency process planning modelling.	Partner	T0+6
	WP 2.2 Development of last version of the model using PLM tools for validation of energy efficiency process planning modelling	Partner	T0+18

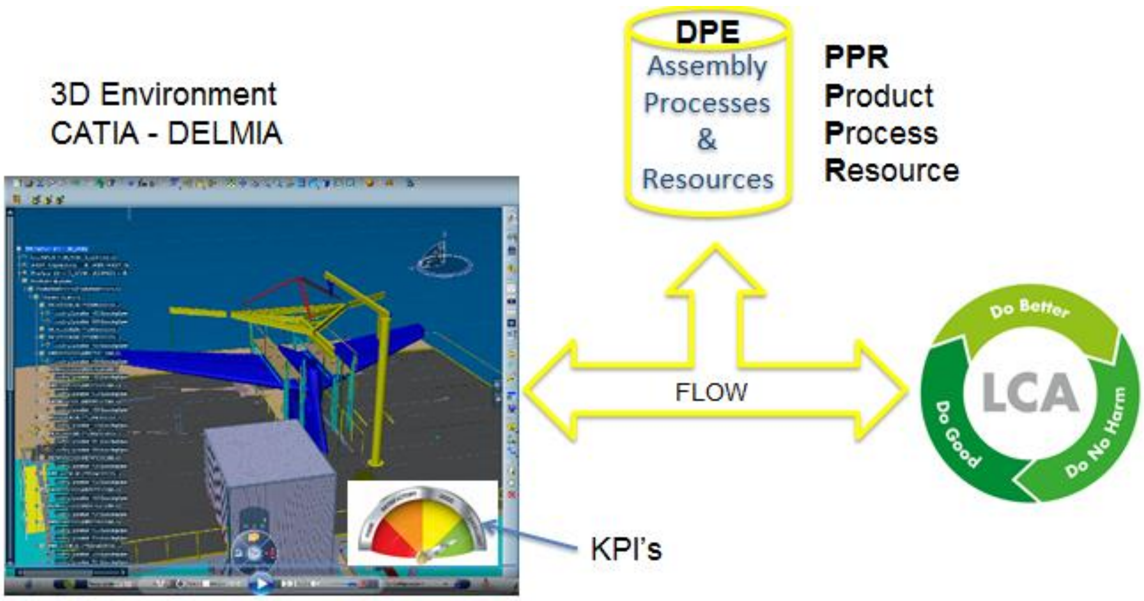
- WP 1. Model Definition

  The purpose of this task is to establish the foundation to support a clean and sustainable production for assembly processes by the definition of a model. This model will be based on the conclusions from tasks previously developed by the Topic Manager (functional and technical requirements) in this project and will be the main input for the development of the model to be built.

  The model definition will propose a framework that will serve as a platform for the development and validation, an architecture to support it, PLM tools needed and the methodology to comply with the functional requirements.

  The activities to be carried out by the applicant are as follows:

  - An information technology development architecture will be proposed to support this project in conjunction with Topic Manager requirements. That architecture must be compatible with the PLM environment of the Topic Manager (CATIA V5 R21, DELMIA V5 R21, and DPE R21). The idea is to develop the process assemblies in a 3D environment, while depending on the resources or assembly technology, the model will reflect how it will be impacted from an eco-efficient point of view.
  - Set up of the architecture at the Topic Manager site.
  - Technical definition of the model. This task will develop the complete model technical definition. It will contain every technical requirement and the best way to be developed when building the model. The model will be represented with UML tools.
  - Architecture communication model for data interchanges between the 3D environment and the LCA application. Information will be asynchronous in a first stage (with HTML or XML) and synchronous for second refinement (SoA or APIs).



- <u>WP2. Model Validation</u>
  The target for this task is to develop and validate the model proposed before, based on a PLM platform and tools.
  The applicant will support the Topic Manager with expertise in development of PLM platforms. The research on eco-efficiency will be validated by developing a model where the main environmental and economical parameters can be evaluated and tested. To analyze the impact on eco-efficiency, a set of KPIs will be provided that will help the process engineer to decide which design is the most beneficial (on costs and environmental impact).

  The activities to be performed by the applicant are as follows:

  - *<u>Subtask 2.1</u> Development of a first version of the model using PLM tools for validation of energy efficiency process planning modelling.*

    The activities included in this subtask are:
    - Development of the model in CATIA 3D environment.
    - This model will contain:
      - An environment for standard task definitions, general attributes (time, number of workers) and eco-efficient attributes if applicable.
      - An environment for resources definitions, general attributes and eco-efficient attributes if applicable.
      - A 3D environment to create the process, create operations and task. Assign product and resources at process, operations or task level. Fill in the needed attributes for each case.
      - An environment to select a process or a product and compute the eco-efficient impact. It will collect the product/process required information to be sent to the LCA application.
      - A user interfaces design for the above entries.
      - An environment to display the KPI's computed by the LCA application.

- A functionality to highlight in DELMIA PPR tree of the processes/tasks which eco-efficient impact are negative.
- A WEB dashboard with a detailed report of the eco-efficient analysis.
- An asynchronous interface between the 3D environment (process/tasks information) and the LCA application. This interface must be bidirectional

This task will be developed entirely by the applicant.

- *<u>Subtask 2.2</u> Development of last version of the model using PLM tools for validation of energy efficiency process planning modelling.*

  This is the second phase for the development of the model with a refined set of requirements and parameters coming from task 1:
    - Synchronous communication between CATIA 3D environment and LCA application.
    - Develop functionalities to compute automatically in CATIA some attributes needed for standard tasks or resources when used in an operation (e.g. volume of material when drilling a hole).
    - Analysis of a process balancing based on resource capabilities (p.eg minimum shifting of a worker when starting the next assembly process). Precedence net of operations/tasks will be required.

  This task will be developed entirely by the applicant.

<u>Activity 2 - Digitalization of ground system test process end to end</u>

This activity aims to develop processes, methods and tools in order to apply the concept of the new concurrent engineering in the field of On Ground A/C functional tests as a solution of the outstanding problems of the On Ground A/C Functional Tests, described above.

Moreover, the objective of this activity is also to implement a RFLP (Requirement, Functional, Logical, Physical) system where the requirements of the systems is integrated with the product. RFLP paradigm enables to define a system based on its fundamentals aspects or facets through essential views and their relations:

- The Requirements and Tests View (R) defines needs and requirements
- The Functional View (F) defines what the system does: Operational (Intended use) and Functional (Internal/Technical).
- The Logical View or architecture View defines how the system is implemented,
- The Physical View defines a virtual definition of the real world product.

The integration with PLM tools platform implies at least to ensure the traceability with engineering data, supported by the link with the PLM model or its storage as "document". This integration shall offer the capability to open the data from the PLM platform. How to do that:

- Strengthen the interfaces manufacturing offices with design offices
- Automation of test means, tools, process and methods
- Standarization of the information related with design requirements, processes and methods
- Dissemination of automation standards throughout the different stages of the process
- Process allowing interconnection of all the actors
- Process test data through data-mining techniques
- Development of new technologies to improve the interaction between users inside A/C during test process.
- Advance of eco-solutions: miniaturization of resources needed during a test process.

The following table summarizes the activities to be performed by the selected partner:

Activity 2 - Work Packages			
Title - Description		***Responsible***	***Due Date***
WP1 GT PLM. Orientation, design and industrialization by requirements	Orientation capacity analysis for the requirements of actuals NTs/GTRs and GTIs/PFs. Needs identification	Partner	T0 + 5
WP2 GT PLM. Tools integration	Concurrence for Model development and establishment	Partner	T0 + 11
WP3 GT PLM & iDMU implementation	Development and deployment of selected solution in CATS	Partner	T0 + 14
WP4 System test visualization in DMU.	WP 4.1-Alternatives for the test process representation in the model (iDMU)	Partner	T0 + 11
	WP 4.2-Design of solution for CATS visual interface to improve troubleshooting	Partner	T0 + 11
	WP 4.3-Development and deployment of selected solution in CATS	Partner	T0 + 11

Specifically:

- WP 1 - Needs assessment to transform current NTs/GTRs and PFs/GTIs to NTs/GTRs and PFs/GTIs oriented to requirements.
- WP 2 - Process definition of Model development from functional test requirement to iDMU.
- WP 3 - Development and deployment of selected solution in CATS to improve the PLM and the contributions of the current testing system for collaborative engineering.
- WP 4.1- Study of alternatives for the test process representation in the selected tool to improve collaborative engineering.
- WP 4.2- Design of solution to make system information available in actual test system (CATS) to improve troubleshooting.
- WP 4.3- Development and deployment of the selected solution for making system information available in actual test system (CATS).

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables Activity 1			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1.1	Model first estimation for development using first version of technical and functional requirements.	Report	T0+1
D1.2	Development of a first version of the model using PLM tools for validation of energy efficiency process planning modeling.	Report, Skill Transfer, Demonstrator	T0+6
D1.3	Development of last version of the model using PLM tools for validation of energy efficiency process planning modeling.	Report, Skill Transfer, Demonstrator	T0+18

Deliverables Activity 2			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D2.1	Orientation capacity analysis for the requirements of actuals NTs/GTRs and GTIs/PFs. Needs identification	Report	T0+5
D2.2	Concurrence for Model development and establishment	Report	T0+11
D2.3	Development and deployment of selected solution in CATS	Report and Prototype	T0+14
D2.4	Alternatives for the test process representation in the model (iDMU)	Report	T0+11
D2.5	Design of solution for CATS visual interface to improve troubleshooting	Report	T0+11
D2.6	Development and deployment of selected solution in CATS	Report and Prototype	T0+11

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 analisys proposed by the applicant will be welcomed.
All the information and data to be exchanged between the Topic Manager and the applicant will be regulated under specific NDA and IPR regulations that will recognise mutually their property following the recommendations and directives of the CS JU.

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

For all those activities, the applicant is required to have deep knowledge in aircraft ground test processes, GTR (Ground Test Requirement) and GTI (Ground Test Instruction) processes, GTI configuration control, requirement management tool DOORs, verifiable CATS (Computer Aided Test System) knowledge at user and CATIA V5 with capability to develop new functionalities. The applicant will also be required to have, additionally to that, deep knowledge of i-DMU and CATIA at programing level and of the different aircraft configuration control techniques.
The applicant will also be required to have, deep knowledge of i-DMU and CATIA-DELMIA V5 at programing level (CAA) and of the different aircraft configuration control techniques.
Capabilities to interface different platforms based on HTML, XML, SoA, APIs.
In addition, the applicant will be required to have verifiable experience in developing SW, and in the engineering and manufacturing of test means in the aerospace sector, and experience in projects related to sustainability manufacturing.
Moreover, it should have the following tools and knowledge to carried-out the work:

- Basic information technology architecture.
- CATIA V5 R21 licenses (for jigs & tools design)
- DELMIA V5 R21 licenses (for PPR, Product-Process-Resource, tree and processes creation)
- DPE R21 licences (for operations, tasks, resource definition and script developments)
- CAA V5 licences and development platform (for development of needed functionalities to manage DELMIA environment and any other required functionalities)

5. Abbreviations

A/C: Aircraft
AIM: Aircraft Interface Module
CAD/CAM: Computer-Aided Design and Computer-Aided Manufacturing
CATS: Computer Aided Test System
DMU: Digital Mock-Up
DIT: Dirección de Ingeniería y Tecnología (Design Office)
ERP: Enterprise Resource Planning
HMI: Human Machine Interface
GT: Ground Test
GTI: Ground Test Instruction
GTR: Ground Test Requirement
ICD: Interface Control Documents
i-DMU: Industrial DMU
NT: Technical Note
PF: Functional Test
PLM: Product Lifecycle Management

XIII. Auto testing technologies and more automated factories for Aircraft validation test process

Type of action (RIA or IA)	RIA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	B-3.6		
Indicative Funding Topic Value (in k€)	400		
Topic Leader	Airbus D&S	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	20	**Indicative Start Date**[51]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-AIR-02-46	**Auto testing technologies and more automated factories for Aircraft validation test process**
Short description	
The objective of this call is to explore further possibilities of new ways to implement quality validation of aircraft products in a more efficient manner, reducing non-recurring costs, reducing the need of man-hours and the involvement of manipulation by an human operator, reducing lead times and flexibility of the processes, through minimization of test means dependency trying to maximize the usage of the current Aircraft computers, and implementing new concepts for the automation of quality and validation tests on the aircraft, through artificial vision and robotic collaboration.	

[51] The start date corresponds to actual start date with all legal documents in place.

1. Background

The framework of this topic is the Clean Sky 2 Airframe *Work Package 3.6: "New Materials and Manufacturing Technologies".* In particular, this topic deals with on-ground testing technologies applicable to airframes which are directly linked to works done by the Topic Manager.
Currently the ground test capabilities of the factories to validate the quality requirement of the aircraft as product are limited in terms of efficiency. This is mainly motivated by two drivers:

1- The need to use high expensive means of tests and devices
2- The workload required for using all the means of tests and performing all the tests required to be in compliance with the quality standards for an aeronautic products

This situation is negatively impacting Airframers following 3 axes:

1- Costs, mainly Non Recurrent Costs through fixed capital,
2- Man-hours requirement, with all the inefficiencies derived from the manipulation of test in large industrial series,
3- Slow and inefficient processes for Quality validation.

The objective of this call is to explore further possibilities of new ways to implement this quality validation of aircraft products in a more efficient manner, addressing the above 3 axes:

1- Reducing Non Recurring Costs,
2- Reducing the need of man-hours and the involvement of manipulation by an human operator,
3- Reducing lead times and flexibility of the processes.

In order to achieve the above objectives, the Topic Manager identifies the need to investigate the following areas:

A) Minimization of test means dependency trying to maximize the usage of the current aircraft computers, with a significant improvement of the versatility and automation of the quality test protocols

B) Implementing new concepts for the automation of quality and validation tests on the aircraft, through

- Artificial Vision,
- Robotic collaboration

2. Scope of work

The topic shall address the following activity lines:

A) Minimization of test means dependency trying to maximize the usage of the current Aircraft computers, with a significant improvement of the versatility and automation of the quality test protocols.
The activity asked to the applicant will be the definition of standard solutions for developing test software into A/C computers, in addition to the utilization of a standard communication protocol to communicate and control the test software from external ground test equipment. In order to develop and demonstrate its feasibility, the solution shall be integrated in a computer installed on on-ground wing demonstrator developed within Clean Sky II. The Topic Manager will provide both SW and HW. The SW and HW are intended to be part of an Aircraft Computer, providing functional test capabilities with minimum impact in Certification, Qualification and Safety criteria. The interface

protocol SW between this adapted Aircraft Computer and the Topic Manager's FAL testing system shall be developed by the applicant.
Having in mind that A/C computers are designed by different suppliers, there is no standardization in terms of test software development and protocols definition, which leads to difficulties while carrying out integration with ground test systems. The end of this process is to find an industrial standard solution for all A/C functional tests.
Moreover, once a standard solution will be defined, the use of on-board test SW will be extended to new aeronautical programs or even already existing ones, after business case studies will demonstrate that economic objectives are met by making use of on-board test software.
The development of the solution shall consist in:

- Studying the test requirements that need to be covered by the utilization of on-board test software.
- Establishing common rules for the development of on-board test software in terms of coding, resources utilization, and scope of utilization.
- Defining a standard communication protocol for controlling the on-board test software from ground test equipment.
- Implementing the defined solution in the aileron driven by EMA that is under development by the Topic Manager.
- Foster auto-testing technologies into A/C Computers.
- Verifying the solution after implementation.

B) Implementing new concepts for the automation of quality and validation tests on the aircraft, through
Currently, during quality validation tests the interaction with the instrumentation of the cockpit is always manual or visual by the technicians who perform the tests in this environment. This create space problems, human derived inefficiencies, long lead times, etc.
In order to automate as much as possible the work in the cockpit, the Topic Manager considers it is possible to achieve a significant improvement through:

- Artificial vision technology: for example, an automated device being able to check the condition of the aircraft by the processed image of the cockpit instrumentation (circuit breakers bad connected, no correct actuation of the cockpit controls and devices, etc.);
- Robotic collaboration: to operate the cockpit controls, instrumentation and devices automatically, taking into account all restrictions of space, human interaction, etc.

The following table summarizes the activities to be performed by the applicant:

Title - Description		*Responsible*	*Due Date*
WP 1. Extended use of test-software for self-testing aircrafts	WP 1.1- Research into aircraft systems where the development of SW test supposes an optimal solution for the testing in FAL: advantages and solved problems	Partner	T0 + 1
	WP 1.2- Conclusions report	Partner	T0 + 11
	WP 1.3-Development/implementation of CATS communication interface	Partner	T0 + 11
	WP 1.4-Prototype development	Partner	T0 + 8
WP 2. Technologies (artificial vision, robotics) for aided interaction with cockpit	WP 2.1 - Concept definition, Process and Methodology definition and Prototype development for aided Artificial Vision	Partner	T0 + 20
	WP 2.2 - Concept definition, Process and Methodology definition and Prototype development for aided Robotic Collaboration	Partner	T0 + 20

A short description of the activities to be performed are described below:

- WP 1.1-
  - Research into the current Final Assembly lines auto-test capabilities and the advantages it is bringing to the process, defining clearly the current architecture being applied and the benefits associated to the process. Corresponding KPIs (lead times, costs, man-hours, inefficiencies, maintenance costs, etc.) consistent with the manufacturing and test validation processes shall be defined in collaboration with the Topic Manager.

- Research into all the aircraft systems and airframe components (mainly flight controls) on the basis of the previous conclusions of the research of what is the room for improvement for the currently non-automated tests processes identified and which concepts shall be applied in order to improve the process. An estimation of this improvement must be done based on the KPIs defined above.

- WP 1.2- Conclusions report on standard's definition and development of test-software for self-testing aircrafts. Formalize the standard of test functionalities defined by Topic Manager for on-board equipment with test capability.
- WP 1.3 - Development/implementation of new communication protocol interface to test-software for self-testing aircrafts prototype. It does mean that the partner will have to develop the SW interface between the Topic Manager's FAL Testing System and the aircraft computer adapted to have auto-test capabilities. The aircraft computer will be provided by the Topic Manager. The appropriate interface must be developed by the applicant so that the test system can interact with test-capable aircraft equipment, and the most appropriate interface protocol will be selected with collaboration of the Topic Manager based on its industrial constraints
- WP 1.4 - Prototype development and integration of the new FAL Ground Test architecture. The applicant must develop and set up the integration of the prototype or device running the adapted Topic Manager's FAL testing system connected with auto-test aircraft computer (to be provided by the Topic Manager). In other words, set up of the integration in order to allow the Topic Manager to perform the final validation of the full concept. Assessment of the benefits expected with the exploitation of this concept in other elements of the cockpit.
- WP 2.1 – Concept definition, Process and Methodology definition and Prototype development for aided Artificial Vision. Demonstration will be done with the device developed showing through appropriate KPIs definition the process improvement. The affected cockpit controls and instrumentation shall be identified, trying to cover the "as much as possible".
- WP 2.2 – Concept definition, Process and Methodology definition and Prototype development for aided Robotic Collaboration. Demonstration will be done with the device developed showing through appropriate KPIs definition the process improvement. The affected cockpit controls and instrumentation shall be identified, trying to cover the "as much as possible". Assessment of the expected benefits with the exploitation of this concept in other elements of the cockpit.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Research into aircraft systems where the development of SW test supposes an optimal solution for the testing in FAL: advantages and solved problems	Report	T0+1
D2	Extended use of test-software for self-testing aircrafts - Conclusions report	Report	T0+11
D3	Development/implementation of FAL testing system communication interface	Report and Prototype	T0+11
D4	Extended use of test-software for self-testing aircrafts - Prototype development	Report and Prototype	T0+8

D5	Technologies (artificial vision for aided interaction with cockpit - Prototype development	Report and Prototype	T0+20
D6	Technologies artificial vision robotics for aided interaction with cockpit - Prototype development	Report and Prototype	T0+20

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 analisys proposed by the applicant will be welcomed.
All the information and data to be exchanged between the Topic Manager and the applicant will be regulated under specific NDA and IPR regulations that will recognise mutually their property following the recommendations and directives of the CS JU.

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

For all those activities, the applicant is required to have deep knowledge in aircraft ground test processes and FAL test system (CATS test system) and automation and robotic technologies in industrial environments The applicant will be required to have verifiable experience in developing SW and in the engineering and manufacturing of test means in the aerospace sector, and experience in projects related to sustainability manufacturing. Moreover, it should have the following tools and knowledge that could hold the work to be carried out:
- Basic information technology architecture.
- Software licenses for developers

5. Abbreviations

A/C: Aircraft
AIM: Aircraft Interface Module
CAD/CAM: Computer-Aided Design and Computer-Aided Manufacturing
CATS: Computer Aided Test System
DMU: Digital Mock-Up
DIT: Dirección de Ingeniería y Tecnología (Design Office)
ERP: Enterprise Resource Planning
HMI: Human Machine Interface
GT: Ground Test
GTI: Ground Test Instruction
GTR: Ground Test Requirement
ICD: Interface Control Documents
i-DMU: Industrial DMU
NT: Technical Note
PF: Functional Test
PLM: Product Lifecycle Management

XIV. Part specific process optimization in SLM

Type of action (RIA or IA)	RIA		
Programme Area	AIRFRAME		
Joint Technical Programme (JTP) Ref.	WP B-3.6		
Indicative Funding Topic Value (in k€)	600		
Topic Leader	Fraunhofer	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	18	**Indicative Start Date**[52]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-AIR-02-47	**Part specific process optimization in SLM**
Short description	
Optimization of the Selective Laser Melting-SLM process for topology optimized aeronautical components such as fittings, based on thermal simulation as well as experimental validation. Process parameters shall be adapted for specific geometric features. All results shall be included in a searchable database and a software module shall be developed that is able to transfer identified parameter schemes to a commercial machine setup.	

[52] The start date corresponds to actual start date with all legal documents in place.

1. Background

Additive Layer Manufacturing (ALM) is a key technology in the approach to minimize the environmental impact of air transportation due to the goals defined in the ACARE 2050 agenda. ALM enables the manufacturing of complex and lightweight structures at low cost and directly from digital geometrical data. Selective Laser Melting (SLM) is a powder-bed based ALM technology that shows high potential to produce high quality metal parts and since recently supplements current manufacturing technologies for aircraft design. To mature the application of SLM to large, complex and heavily loaded components, such as fittings for cargo doors the part quality is to be elevated and the whole process chain needs to be investigated.

ALM technologies are strongly linked to topology optimization as a simulation based design approach. This is due to the possibility of manufacturing very complex topology optimized designs and thus reducing the weight of aircraft components by possibly high margins. Currently SLM parts are manufactured based on standardized parameter sets of machine vendors and minor adaptions of operators using predetermined schemes. Those schemes are not able to deal with complex geometries with varying dimensions of topology optimized parts. The process of exposure of metal powder and selective melting depends on the locally inducted energy as well as energy transport and thermal environment. Therefore the thermal process is highly related to the geometry of the part.

Finding parameter sets for topology optimized parts currently means to rely on the operator's experience and also to conduct a certain amount of experiments in order to find suitable parameter sets. Also for very complex geometries, the adaption of machine vendors' predefined schemes might not suffice to come to terms with the geometric complexity of parts. Still, the quality of every SLM produced part is relying on its own part specific suitable parameter set which currently remains to be a cost and time intensive procedure.

2. Scope of work

The topic addresses the development of a methodology in order to adapt SLM-process parameters to geometric characteristics of topology optimized parts in an effective way and independent from machine vendors' parameter schemes. The applicant is expected to conduct studies on the systematic adaption of laser and process parameters for specific geometric features that are relevant to topology optimized designs of metal aircraft parts and particular to fittings of cargo doors that are to be manufactured from AlSi10Mg.

All results of the parametric study are to be included in a searchable database. Based on the created data, a software-tool will be developed which will be able to propose different setups of manufacturing parameters. An automatic transmission to commercial machine setups shall be possible through a Transfer Software package.

The Topic Manager will provide the applicant with complex geometrical data with relevance to topology optimized metal parts. The activity is to be based on thermal simulation (performed with a commercial or non-commercial software) of the build-up process as well as experimental studies and process implementation in a laboratory environment at relevant scale. In a laboratory machine setup, exposure and other process parameters e.g. layer thickness and exposure strategy can be varied and steered in different areas of the part and throughout the build-up process in order to enhance the quality of manufactured samples in terms of criteria such as homogeneity (incl. imperfections), surface quality and thermally induced stresses.

While a complete simulation of the manufacturing process will be limited regarding complex cases, enhanced information about the process should be gained by experimental studies through sample manufacturing. Here it is important to inquire the exposure strategy (e.g. arrangement of laser tracks, line spacing, up and down skin, overlap etc.), the exposure parameters (e.g. exposure speed, laser power), machine parameters (e.g. layer thickness, platform heating etc.) as well as the change of exposure for certain areas (e.g. different exposure for core, contour and adjustments for slender areas). Since the area close to the surface is crucial to the mechanical performance and fatigue behavior, the exposure of the contour shall be a key aspect of the experimental studies. To quantify the part quality, different testing methods shall be applied (e.g. µCT, metallographic analysis, Laser Scanning Microscope, Acoustic Sound Microscope, hardness measurement or other common material test methods etc.). The applicant will conduct sufficient experiments to preserve stochastically significant results and will include results and parameter sets in a searchable database system. Based on this, a software module will be developed that allows transfer of derived process parameters to commercial vendors' machine setups to enable an automatization of the part specific optimization of manufacturing parameters.

It is proposed to structure the technical activities by using the following Work Breakdown Structure*:*

WP1 – Laboratory setup - process control and calibration
The laboratory setup is to be calibrated and reviewed. The laser control system shall be able to fulfill the requirements for the transient adaption of process parameters during the build-up process with AlSi10Mg as the material system.
The laboratory machine setup shall be based on a fiber laser with min. 400W but preferably 1000W power output. Adaptable process parameters in laboratory setup will include but not be limited to the control of:

1. Laser tracks by vector input data
2. Laser power and speed with transient adaption along vectors
3. Layer thickness adaption within building-job
4. Platform heating of up to 500°C

Furthermore: inert gas atmosphere and fluid flow control, measurement of laser caustic and temperature distribution throughout the process.
A parameter scheme for a reference sample of simple geometry (e.g. cube, cylinder) with homogeneous microstructure (also in near surface areas), homogeneous surface quality and adequate mechanical properties is to be developed. Additionally, it needs to be confirmed that the parameter scheme has adequate performance in terms of induced thermal stresses.

WP2 – Thermal Simulation and experimental validation
For the calibration of the thermal process simulation with the laboratory setup samples shall be manufactured and characterized. This shall include but is not limited to the measuring of laser penetration width and depth related to laser power, scanning speed, layer thickness etc. Results will serve as input for the process simulation. A relation is to be developed and calibrated between experimental results from the laboratory setup, e.g. energy distribution during build-up, to the thermal simulation process in a way, that the adaption of process parameters in the thermal process simulation can forecast quality criteria.

The simulation shall be able to model as many layers of exposure in one routine that are relevant to the selective melting process and sphere of influence of the laser energy input. In addition, the simulation shall be able to include effects of support structures and platform heating.
The process simulation shall have a significant forecast ability on the adaption of process parameters. The applicant needs to prove this ability on a sample with relevant scale.

WP3 – Sample simulation, manufacturing and testing
A systematic study to find sufficient parameter sets for the manufacturing of geometric structures of topology optimized parts is to be conducted and results are to be included in a searchable database. The build-up process of each geometric sample shall be simulated and simulation results shall be used to adapt parameters for the manufacturing process. Samples are to be manufactured and characterized in terms of quality criteria.
Geometric structures and variations shall include but are not limited to the following:

- Truss structures with varying dimension, cross section and overhang angle.
- Hollow truss structures with varying wall thickness.
- Truss junction of three, four and five connected trusses with angle variations.

The sample matrix, number of variations and characterization is to be agreed on with the project manager, based on reference samples and expected deviations.
The transferability on parameter sets of broader variations shall be demonstrated and well-founded suggestions shall be made how the database could be effectively expanded.

WP4 – Parameter Database and Transfer Software
A searchable database is to be developed and all results from the parametric study shall be included in this database. The database will be able to propose different setups of manufacturing parameters by means of search criteria. An automatic transmission to commercial machine setups shall be possible through a Transfer Software package.
Basic Requirements for the Parameter Database:

- Effective classification and correlation of geometric features (e.g. cross section, overhang angle, wall thickness, number of junction partners, exposure area in xy-plane, …) to process parameters and quality criteria
- Inclusion of experimental results and expandability
- Effective search methodology

Basic Requirements for the Transfer Software:

- Preparation of the digital input data to the vendor's machine
- Applicable to multiple vendors' machine systems
- Interface to parameter database
- Correlation of database input to part specific parameter set
- Adaption of part specific parameter sets to vendors' parameter schemes

3. Major Deliverables/ Milestones and schedule (estimate)

Major Deliverables and Milestones are summarized in the tables below. Depending on the work description, this list can be extended where necessary.

Deliverables			
Ref. No.	*Title - Description*	*Type*	*Due Date*
Del.1	Concept review	Report	T0+6
Del.2	Sample matrix and test matrix	Report	T0+6
Del.3	Simulation and sample testing report	Report	T0+12
Del.4	Delivery of Parameter Database	Software	T0+18
Del.5	Delivery of Transfer Software	Software	T0+18
Del.6	Final report	Report	T0+18

Milestones		
Ref. No.	*Title - Description*	*Due Date*
M1	Laboratory setup review	T0+6
M2	Thermal simulation review	T0+6
M3	Sample matrix agreement	T0+6
M4	1st Database review	T0+10
M5	Transfer Software specification review	T0+12
M6	2nd Database review	T0+15
M7	Critical Transfer Software design review	T0+15
M8	Final Database review	T0+18
M9	Final Software test and final meeting	T0+18

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

- The applicant shall have expertise in the field of:
  - Selective Laser Melting of Metals (or comparable: Lasercusing, Direct Metal Laser Sintering), preferably expertise with AlSi10Mg
  - Control systems of laser optics
  - Process control software and software development
  - Thermal process simulation
- The applicant shall demonstrate capabilities to:
  - Manufacture SLM samples at relevant scale
  - To integrate thermal process control in a laboratory SLM setup with control of laser optics and transient control of process parameters during build-up process
  - Perform tests to quantify quality criteria of SLM samples

XV. Development and validation of a portable, automated and jigless system for drilling and assembly of fuselage joints

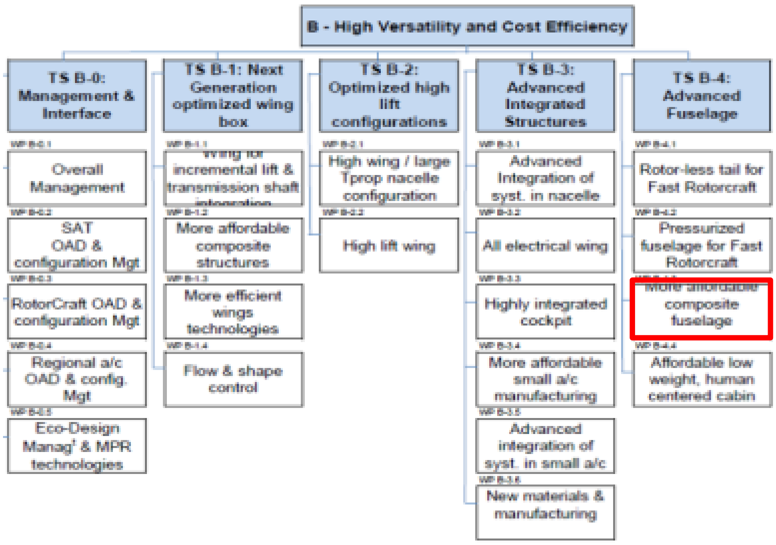
Type of action (RIA or IA)	IA		
Programme Area [SPD]	AIR		
(CS2 JTP 2015) WP Ref.	WP B-4.3		
Indicative Funding Topic Value (in k€)	900		
Topic Leader	Leonardo Aircraft	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[53]	Q1 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CfP06-AIR-02-48	**Development and validation of a portable, automated and jigless system for drilling and assembly of fuselage joints**
Short description	
An automated system shall be developed to operate in a very flexible way, for panel longitudinal joints and barrel circumferential joints. Thanks to a jigless and portable architecture, the system shall follow the actual outer surface, moving on it with a suitable indexing and holding device. The system shall demonstrate the capability to drill in an accurate way and to insert sealant and fasteners, this in order to achieve the one-up process with significant flow reduction. After machine development and validation, the system will be used at TM facilities on a regional a/c fuselage full scale demonstrator.	

[53] 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 the framework of Airframe ITD. In particular, Work Package B-4.3 "More Affordable Composite Fuselage" which is incorporated within the Technology Stream B-4 represents the location where activities requested to the Applicant will be performed. The relevant ITD Work Breakdown Structure is shown below by highlighting WP B-4.3 location:



More specifically, the activities of WP B-4.3 will drive the maturation of technologies started in Clean Sky programme for the industrialization of a composite fuselage of a Regional Turbo Prop aircraft, in terms of increased structural integration, reduced total costs and structural weight, increased automation, reduced environmental impact and extended duration of A/C life.

2. Scope of work

The scope of the present Topic is the development and validation of a flexible system for automated drill integrated holes inspection to be used for a regional aircraft composite fuselage assembly. Use of the system will allow a significant reduction of the overall production costs and flow.
The system will consist in a compact equipment, movable on curved surfaces, and able, through a dedicated Part Program, to perform one-shot drilling and hole inspection for assembly of primary structures. This solution will address longitudinal/circumferential joint of fuselage sections.
After the developmental phase, the innovative process and related machine shall be validated and costs assessed through the execution of dedicated tests at Topic Manager's facilities. After positive validation, the system will be used for REG IADP full scale demonstrators assembly.
The tool can be divided into three main components; each of them will be developed and designed, with a particular attention to efficiency, automation and innovation:

- Drilling head, capable to drill and countersink in one pass full size holes, equipped with hole/countersink measurement system and adequate dust/chip suction system;
- Head moving system, made by vacuum rails or vacuum arms or other systems in order to allow the drilling head to move to all hole locations, both in X and Y axis, all around the

fuselage, for panel longitudinal lap joints and barrel circumferential joints.
- Positioning, normalizing and alignment system, to allow the tool to align on DA holes (Determinant Assembly holes), to self-adjust normal to drilling surface and to set the drilling stroke taking into account also the countersink depth. The tool has to be equipped with servo axis control and portable NC.

The tool shall be developed as an innovative integrated system of these main components, and, after acceptance test, will be tested on the final demonstrator.

All the auxiliary systems, tools, equipment that are needed for the use and the handling of the tool shall be provided by the partner. Moreover, the partner will provide all the tools needed for the NC programming activities (i.e. a PC or laptop and all the software including licenses).

To achieve the proposed objectives, the main activities to be performed are:

- Trade-off study in terms of cost, production rate and level of technology among a set of tools and processes configurations for the activity of interest: automated drilling and hole/countersink inspection on fuselage barrel;
- Tool design, comprehensive of the three main components: drilling and hole/countersink inspection head, head moving equipment (both X and Y axis, in order to move on the surface of the fuselage, for panel longitudinal joints and barrel circumferential joints) and positioning and alignment system;
- Test Plan definition to assess the main mechanical and technological characteristics of the drilling and hole inspection equipment;
- Test Plan definition to assess the main mechanical characteristics of the head moving equipment;
- Test Plan definition to assess the main characteristic of the positioning and alignment system;
- Equipment development as an integrated system based on the results of the tests and construction;
- Pre-acceptance tests at the partner's site including functional and manufacturing trials (on flat and curved panels);
- Tool shipment to the Topic Manager plant and tool assembly;
- Acceptance tests and repeatability tests;
- NC integration (which will include NC training for personnel working at Topic Manager's facilities);
- Usage on final demonstrator with the identified process.

The activities to be performed are divided into the tasks listed in the following table:

Tasks		
Ref. No.	***Title - Description***	***Due Date***
1	Trade-off Study and Machine Technical Specification	T0 + 3
2	Equipment design	T0 + 6
3	Test Plan of the three main components and their integration	T0 + 6
4	Equipment development and construction	T0 + 17
5	Pre-acceptance tests	T0 + 18
6	Equipment Acceptance	T0 + 21
7	Fuselage Demonstrators Drilling and Fastening	T0 + 24

The following inputs shall be provided to the Topic Manager:

- Equipment mechanical/ electrical/ pneumatic drawings and schemes.
- Test Plan (agreed with the Topic Manager) of the three main components and their integration;
- Equipment Usage and Maintenance Manuals;
- Spare parts, with technical sheets, and vendor lists;
- PC with software for NC programming and Equipment Control (with applicable licenses).

For the project execution the Topic Manager Company will provide test panels (aluminum and carbon composite), Mock-up Shear Tie Clips, sealant cartridges and fasteners for preliminary and acceptance tests. Drill-bits will be defined by the Topic Manager and they will be acquired by the Applicant until the Equipment will be accepted. Tooling and Assembly jigs are under Topic Manager responsibility and Tooling general architecture will be provided by the Topic Manager. Quality/ dimensional requirements and parts 3D models (environment CATIA V5R21) will be provided by the Topic Manager when required by the partner.

Task 1 - Trade-off Study and Tool Technical Specification

The advanced technologies development for an automated drilling system on the Regional Turbo Prop fuselage shall be driven by the following key factors: increase of integration, reduction of assembly flow, reduction of assembling costs and increase of automation.

The following processes shall be investigated, among the actual state of art:

- Automated drilling of composite structure, with particular attention to quality requirements, innovation and high automation level;
- Automated measurements of drilled holes and countersinks, with particular attention to accuracy requirements, innovation, system integration and high automation level;
- Automated positioning of the equipment, capability to read and adjust position using Determinant Assembly Holes and automated normalizing with respect to a given surface.

The equipment shall be shipped and put into operation at Topic Manager premise. The equipment shall be capable to move on the wholes surface of an aircraft fuselage, at specific locations (panel joints) without use of a jig.

For each of the above three processes, the partner shall evaluate and propose different solutions in terms of configuration, and for each of them a comparison, in terms of cost, production rate and level of integration. This shall be done in conjunction with the Topic Manager.

A complete technical specification shall be prepared as answer to the above request. It shall include at least:

- Trade-off study
- Chosen equipment configuration;
- Productivity data;
- Process parameters;
- Equipment acceptance test proposal.

Task 2 – Equipment design

Equipment shall be designed to fully satisfy the requirements described in this document.

Equipment shall be an integrated system of the three main components: drilling and measuring head, head moving equipment (both X and Y axis, moving on the fuselage, at specific locations for panels joint) and positioning and alignment system, as reported previously.

Also handling features need to be taken into account into the design.

Some (but not limited to) main characteristics of the equipment shall be:

- Capability to work with the geometries described in this document and within drawing tolerances;

- Capability to drill holes sided up to 5/16" (7.94 mm) in one pass on composite-composite and Aluminum-aluminum joints. Future extension of application to hybrid stack-up (CFRP/metal) shall be taken into account (e.g.: head interchangeability depending on application);
- One Up Assembly process capability: drilling with no contamination occurring at the joint interfaces or at the exit of the hole so that part shall not be disassembled for checking, cleaning, deburring, repairing as applicable;
- Capability for automated adjustable force application with pressure foot bushing (from outside);
- Pressure foot bushing design to prevent damage (scraps and footprints) on the outer side surface or interference with the demonstrator barrel elements (i.e. fasteners heads, lap joints, etc.);
- Alignment system required for the production of the hole/countersink normal to the surface;
- Capability to adjust process parameters depending on the cutting forces;
- Fastener selection, handling, feeding, insertion and installation capabilities implementation are optional. Partner will evaluate how and if implementing fastener features.
- System of thrust force records;
- Drill bit cooling and lubricant system (continuous or pulse);
- Peck drill system with the regulation of the pulse and travel;
- Automated hole and countersink measurement through an integrated system which may be using (but not limited to) conventional mechanical probes, laser, optical technology;
- Portable NC and remote control with a smart Human Interface;
- Vacuum rails system with vacuum pump or other support and movements system for the translation on the external surface of the demonstrator (see Fig.1 as reference);
- Restraint safety system to prevent the falling or unexpected movement of the system in case of failure or missing air/electrical power all around (360°) the fuselage demonstrator;
- Functionality of a 5 axis tool, translation axis X and Y, drill mandrel translation and rotation axis Z, A, B;
- Lower cost than large dedicated tools;
- Capability for DA hole position detection, normality sensing, panel distance sensing, X & Y moving. Hole detection will be efficient in any environmental light condition;
- Adequate suction system shall be provided for composite dust and metal chip collection;
- Capability of moving on the fuselage, at specific locations for panels joint (butt splice and overlap configuration). In case of presence of window frame or door surround, the necessity to develop special tools to guarantee the complete movement of the equipment on OML surface will be shared with the Topic Manager before the technical review of the system.
- Each component of the system will be portable (in the respect of the Safety and Health European laws) and capable to operate in an industrial environment. If the weight exceeds the laws limits, the developments of a handling system to transport the equipment on the OML surface will be shared with the Topic Manager. Handling system will be provided with the equipment by the partner;
- Each device will be proof to carbon fiber dust to prevent damages as foreseen in the

European laws;
- Safety devices to prevent damages of the equipment or part of it and to prevent damages of the operators (i.e. emergency buttons);
- Anti-collision system used to prevent damage of the equipment with obstacles on the outer surfaces.

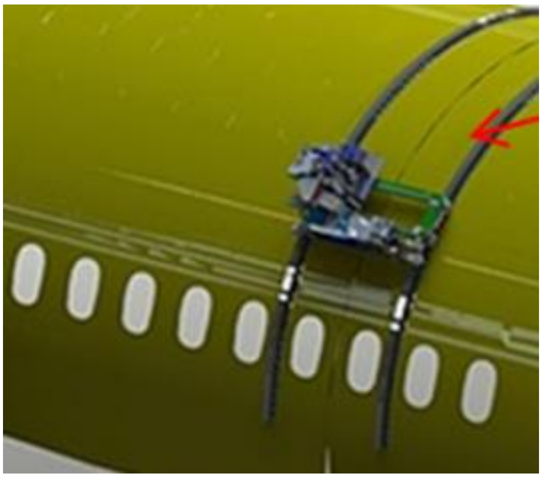


Fig. 1 – Example of compact drill equipment and rail system.

Task 3 - Test Plan of the three main components and their integration

After design, a Test Plan for each of the three main components shall be produced by the Applicant (document will require Topic Manager's approval), listing and describing all the tests that have to be conducted to develop the process.

Equipment shall satisfy the requirements listed in this document. In addition, relevant quality/ dimensional requirements applicable to the standard aeronautical practice shall be met.

The Test Plan has to take into account all the characteristics requested to the equipment, and all the possible combinations of factors. The scope of the Test Plans is to allow a complete verification of the solution individuated during the previous trade-off analysis.

Task 4 - Equipment development and construction

Equipment shall satisfy all design requirements. Tests required by plans shall be conducted during the equipment construction, thus supporting and orienting the development of the automatic equipment.

Task 5 – Pre-acceptance tests

A pre-acceptance phase shall be conducted before equipment shipping to the Topic Manager's plant in order to verify technology readiness and conformance to the requested performance level. Pre-acceptance minimum requirements and relevant quality criteria will be communicated by the Topic Manager.

A dedicated test book shall be prepared by the Applicant (document will require Topic Manager's approval) including functional and manufacturing trials (on flat and curved panels, approx. dimensions of curved panels are 1mx1m). Tool for holding /handling curved panel shall be designed / assembled by the Applicant.

The outputs of this task shall be:
- Process/ equipment set-up for all the different combination of stack-up (which are Composite-Composite and Aluminum-Aluminum);
- Definition (even if preliminary) of the main Key process parameters;

- Estimated level of quality and positioning accuracy.

After the completion of this task, the tool shall be disassembled and shipped to the Topic Manager’s plant.

The partner will have the complete responsibility of Equipment shipping and putting in operation at Topic Manager’s plant in terms of required personnel, handling tools, safety cost. At Topic Manager’s facilities, an overhead crane (5 tons.) will be available at the area where the tool will be put into operation. Temporary storage area and yard area will be defined in accordance with the Topic Manager Company and in any case as required from the Safety and Health European Laws.

Task 6 - Equipment Acceptance

An acceptance task, similar but more in depth than pre-acceptance, shall be performed after final installation in the Topic Manager facility. A full-size demonstrator shall be successfully drilled, checked and assembled in order to validate the Equipment capabilities (6 longitudinal joints, 1 orbital joint). Acceptance minimum requirements and relevant quality criteria will be communicated by the Topic Manager.

The outputs of this task shall be:

- Final process/equipment set-up for all applicable of stack-ups;
- Complete definition of the main Key process parameters;
- Compliance with the requested level of quality and positioning;
- NC part program of drilling and assembly of panels and sections (for full demonstrators);
- Training for programming (NC), usage and maintenance for personnel working at Topic Manager’s facilities.

Task 7 - Fuselage Demonstrators Drilling and Fastening

Equipment shall be tested on the final planned demonstrator.

The partner shall provide the required operational and engineering support for drilling and assembly operations of one demonstrator (6 longitudinal joints and 1 orbital joint).

Maintenance, technical assistance and spare parts shall be guaranteed by the partner until the completion of all the activities planned within the ITD that will require the use of the equipment (2 full complete demonstrators, 12 panels).

Additional Technical and organizational information is herein reported:

The demonstrator is composed by 2 sections, each section is composed by 3 panels (6 panels in total). The panels are jointed through overlaps (3 per section, 6 joints per demonstrator), sections are orbital jointed through butt strap (1 orbital joint per demonstrator).

Figure 2 represents the three panels composing section, Figure 3 shows two sections jointed.

Max dimension for panel: 3.8m x 3.2m x 1.72m (length x chord x radius)

Min dimension for panel: 3.4m x 2.54m x 1.72m (length x chord x radius);

General dimensions are shown in Fig. 4.

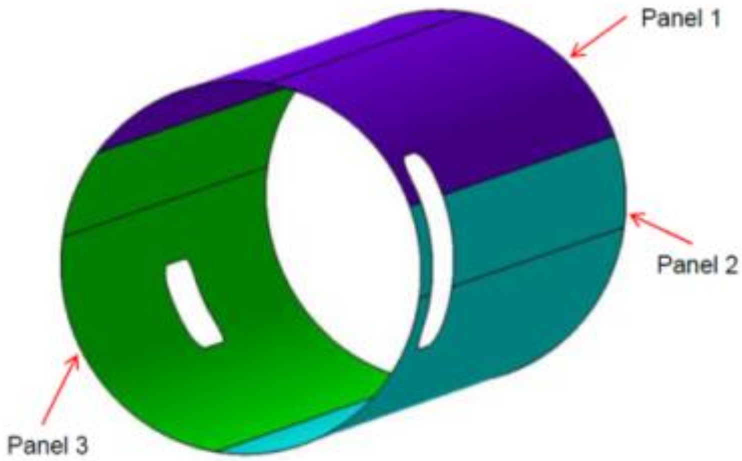


Fig. 2: Section composition

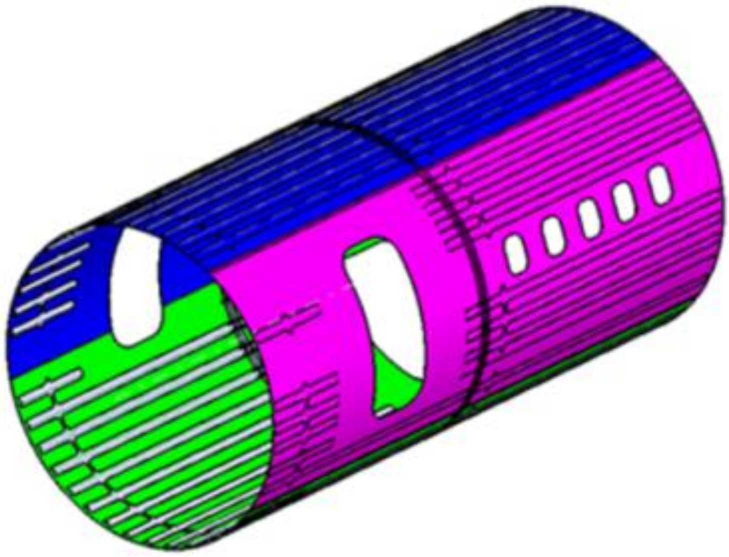


Fig. 3: Joined parts

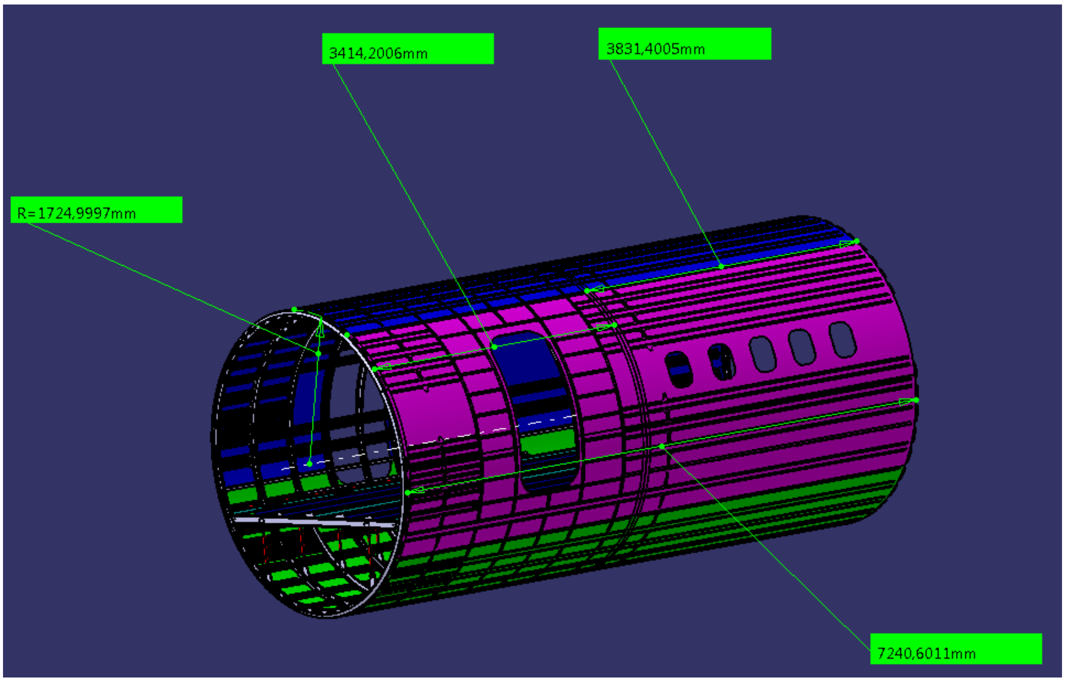


Fig. 4: General dimensions

Typical fastener system to be considered is represented in Figure 5 (Hi-lok). Pin/ Collar insertion and installation shall be performed by hand or using the tool as an option. This information is reported as reference for holes characteristics.

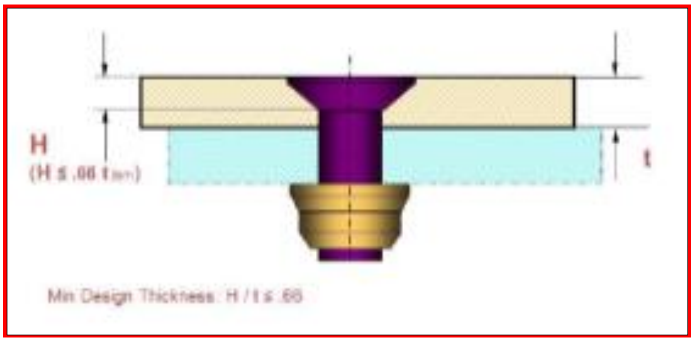


Fig. 5 – Typical fastener system (hi-lok)

A sketch of panel joint is represented in Fig. 6.

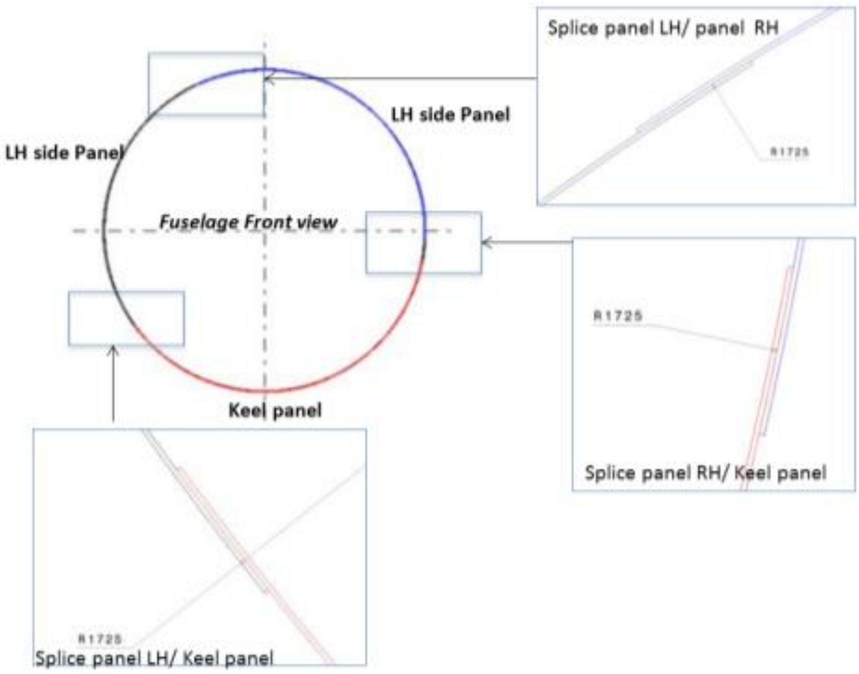


Fig. 6 – Scheme for panels joint (Section).

Panel material (skin): carbon composite.
Productivity time requested: 20 sec. per hole floor to floor drilled (Takt time).
Panel Thickness range: 2-6 mm.
Hole position tolerance: ±0.2 mm.
Countersink depth repeatability requirement: ±0.025 mm on depth (3σ analysis).
Edge Margin: min. 2.5D + 1mm (D= nominal hole size), respect to the flange edge (consider hole axis).
Hole size tolerance: [0, +0.076mm].
Allowed delamination (holes): 1 mm in width on the radius, 0.2mm in depth (1 ply). (Fabric)
Countersink angle: 100° ±2°.
Max Hole angularity allowed: ± 2°.
With respect to the lay-out available for Equipment which will be put into operation at Topic Manager Plant, the area dimensions are approx. 10m x 5m and will be provided with overhead crane (5 tons.). The area will be equipped by the Topic Manager with all the supplies requested for Equipment functionality (Power, air, vacuum) according to Technical Specifications provided by the applicant at the time of M2 (milestone). Electrical panel, electrical transformer, vacuum and pneumatic adapters will be provided by the partner for the connection with Topic Manager's plant building utilities.
See Fig. 7 for reference Layout. Area is enlighted in red. Fig. 8 shows the full section and operation platform for reference (floor installation is out of topic).

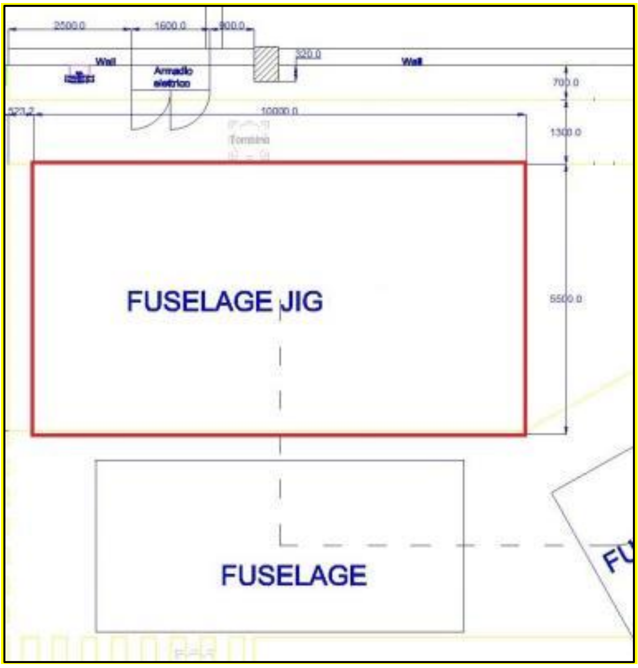


Fig. 7: Reference lay-out

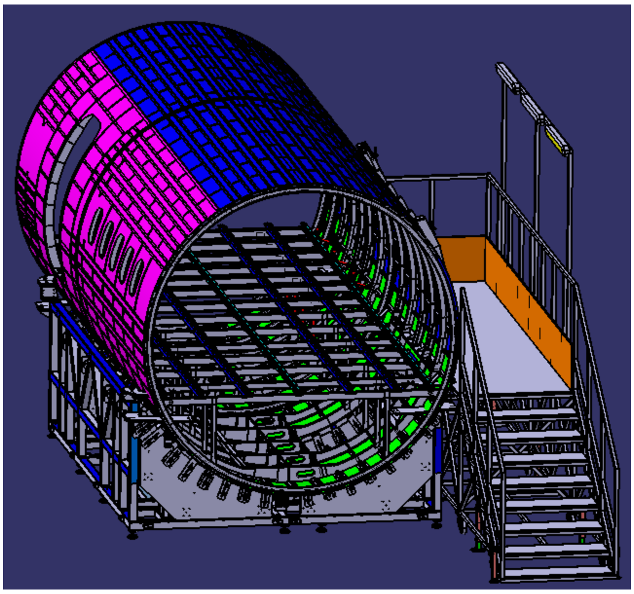


Fig. 8: Full section platform lay-out

3. Major Deliverables/ Milestones and schedule (estimate)

	Deliverables		
Ref. No.	***Title – Description***	***Type***	***Due Date***
D1.1	Machine Configurations Trade-off Analysis	Report	T0 + 3
D1.2	Machine Technical Specification	Report	T0 + 3
D2.1	Equipment Design: description report	Report	T0 + 6
D2.2	Equipment Design: drawing	Drawing	T0 + 6
D3.1	Test Plan: drilling/ hole inspection tool	Report	T0 +6
D3.2	Test Plan: moving and alignment system	Report	T0 + 6
D4.1	Test Report	Report	T0 + 16
D4.2	Equipment Construction	Hardware	T0 + 16
D4.3	Part Program	PP	T0 + 17
D4.4	CN procedure, routines description, maintenance book	Report	T0 + 17
D5.1	Pre-Acceptance Test Book	Report	T0 + 16
D5.2	Pre-Acceptance Tests and Report	Hardware + Report	T0 + 18
D6.1	Equipment installation/ shipping at/to TM Plant	Hardware	T0 + 20
D6.2	Acceptance Test Book	Report	T0 + 19
D6.3	Part Programs	Part Program	T0 + 20
D6.4	Acceptance Tests and Report	Report	T0 + 21
D7.1	Final Manufacturing and Cost Assessment Report	Report	T0 + 24

*Types: R=Report, D-Data, HW=Hardware

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M1	Trade-off analysis: description report	Report	T0 + 3
M2	Equipment Design: description report	Report	T0 + 6
M3	Equipment Construction	Hardware	T0 + 16
M4	Equipment installation/ shipping at/to TM Plant	Hardware	T0 + 20
M5	Acceptance Tests and Report	Report	T0 + 21
M6	Final Manufacturing and Cost Assessment Report	Report	T0 + 24

*Types: R=Report, D-Data, HW=Hardware

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

- Skill 1: Proven competence in design and construction of equipment for aeronautical composite components assembly, by a documented experience in participating in actual aeronautical program. This competence shall include a strong knowledge of processes, quality, tooling, part programs for CN machines.
- Skill 2: Proven experience in experimental testing from coupon levels up to aeronautical full scale substructures. Evidence of qualification shall be provided.
- Skill 3: Proven experience in cost estimation at industrial level for aeronautical full scale composite structures.

5. Abbreviations

WP	Work Package
NC	Numerical Control
A/C	Aircraft
PP	Part Program
PC	Personal Computer
OML	Outer Mold Line
TM	Topic Manager

XVI. Development and validation of a self-adaptive system for automated assembly of major composite aerostructures

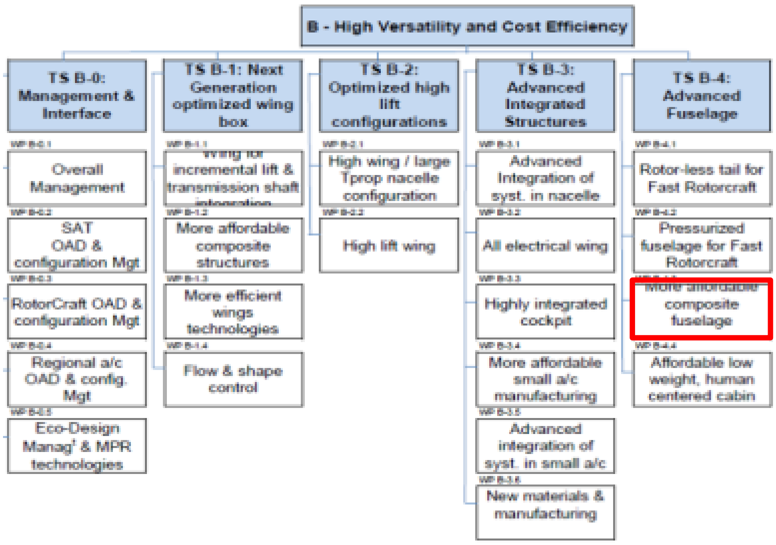
Type of action (RIA or IA)	IA		
Programme Area [SPD]	AIR		
(CS2 JTP 2015) WP Ref.	WP B-4.3		
Indicative Funding Topic Value (in k€)	2000		
Topic Leader	Leonardo Aircraft	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	30	**Indicative Start Date**[54]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-AIR-02-49	**Development and validation of a self-adaptive system for automated assembly of major composite aerostructures**
Short description	
An automated system shall be developed for the assembly of regional aircraft composite fuselage panels, by means of innovative features for recognition of actual position and shape of parts to be drilled, with the aim to generate the correct pattern of holes with "best fit" algorithm to be developed. Application will be the assembly of skins, stringers, frames and door surround components. After the development phase, the innovative process and related tool shall be validated and costs assessed through the execution of dedicated tests at Topic Manager plant where it will also be used for regional aircraft fuselage full scale demonstrator.	

[54] 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 the framework of Airframe ITD. In particular, Work Package B-4.3 "More Affordable Composite Fuselage" which is incorporated within the Technology Stream B-4 represents the location where activities requested to the Applicant will be performed. The relevant ITD Work Breakdown Structure is shown below highlighting WP B-4.3 location:



More specifically, the activities of WP B-4.3 will drive the maturation of technologies started in Clean Sky programme for the industrialization of a composite fuselage of a Regional Turbo Prop aircraft, in terms of increased structural integration, reduced total costs and structural weight, increased automation, reduced environmental impact and extended duration of A/C life.

2. Scope of work

The scope of the present Topic is the development and validation of self-adaptive system for automated assembly of major composite aerostructures of a regional aircraft composite fuselage which will allow a significant reduction of the overall production costs and flow.
The system will consist in a 7-axis anthropomorphic automatic robot equipped with end effector for drilling/countersinking, sealing and fastener insertion (7-axis is for reference, number of axis can be higher or lower). This solution will be applied for the assembly of stiffened panel skins, frames, window frames and door surround components.
Recognition of actual position and shape of sub structure is performed by a dedicated camera system, so that a specific algorithm will elaborate the 3D model holes pattern on the basis of the actual structure position and profile. Camera system and algorithm shall be able to perform visual and dimensional checks (e. g.: burrs, hole diameters, hole position, delaminations) by matching the actual data with requirements, and providing report.
After the development phase, the innovative process and related tool shall be validated through the execution of pre-acceptance test at the Applicant plant and dedicated acceptance tests at Topic Manager facilities where the system will be installed. After positive validation, the system will be

used for REG IADP full scale demonstrators assembly.
The tool can be divided into three main components, each of them will be developed and designed, with a particular attention to efficiency, automation and innovation:
- Drilling and fastening (only fastener insertion) head, capable to drill and countersink in one pass full size holes both in composite and in metal structures, equipped with sealing tool, hole/ countersink measurement system, drill bit storage and adequate dust/chip suction system. These activities shall be performed from outer side of the panel.
- Positioning and alignment system/ machine, able to scan through a vision system from internal side of the panel so that drilling pattern is then adapted to the actual geometry of the sub-structure. Software for in-process computing shall be developed.
- Two robotic arms moving on rails, in order to allow the drilling head moving to all hole locations and the vision system moving for the operations. The robots architecture and all the NC programs shall be defined in order to avoid interferences with the assembly jigs that hold, handle and clamp the composite fuselage panels assemblies.

The tool shall be developed as an integrated system of these main components, and, after acceptance test, will be tested on the final demonstrator.
To achieve the proposed objectives, the main activities to be performed are:
- Trade-off study in terms of cost, production rate and level of technology among a set of machines and processes configurations for the activity of interest: automated drilling and fastener insertion on fuselage panel, geometrical feature recognition and inspection;
- Tool design, comprehensive of the three main components: drilling and fastening (sealing and insertion) head, head moving equipment and vision, analysis, positioning and alignment system;
- Test Plan definition to assess the main hardware and technological characteristics of the drilling and fastening head;
- Test Plan definition to assess the main hardware characteristics of the head moving robots;
- Test Plan definition to assess the main characteristic of the vision, analysis, positioning, alignment and inspection system;
- Equipment development as an integrated system based on the results of the tests and construction;
- Pre-acceptance tests at the Applicant site including functional and manufacturing trials (on flat and/or curved panels);
- Machine shipment to the Topic Manager plant and tool assembly;
- Acceptance tests and repeatability tests;
- NC integration (which will include NC training for personnel working at Topic Manager facilities);
- Usage on final demonstrator with the identified process.

The activities to be performed are divided in the tasks listed in the following table:

Tasks		
Ref. No.	***Title - Description***	***Due Date***
1	Trade-off Study and Machine Technical Specification	T0 + 3
2	Equipment design	T0 + 6
3	Test Plan of the three main components and their integration	T0 + 6
4	Equipment development and construction	T0 + 19

Tasks		
Ref. No.	***Title - Description***	***Due Date***
5	Pre-acceptance tests	T0 + 20
6	Equipment Installation and Acceptance	T0 + 24
7	Fuselage Demonstrators Drilling and Fastening	T0 + 30

The following inputs shall be provided to the Topic Manager:
- Equipment mechanical/ electrical/ pneumatic drawings and schemes;
- Test Plan of the three main components and their integration;
- Equipment Use and Maintenance Manuals;
- Spare parts, with technical sheets, and vendor lists;
- PC with software for NC programming and Equipment Control (with applicable licenses).

For the project execution the Topic Manager Company will provide test panels (aluminum and carbon composite), Mock-up Shear Tie Clips, sealant cartridges and fasteners for preliminary and acceptance tests. Drill-bits will be defined by the Topic Manager and they will be acquired by the Applicant until the Equipment will be accepted. Tooling and Assembly jigs are under Topic Manager's responsibility and Tooling general architecture will be provided by the Topic Manager. Quality/ dimensional requirements and parts 3D models (environment CATIA V5R21) will be provided by the Topic Manager when required by the partner.

Task 1 - Trade-off Study and Tool Technical Specification
The advanced technologies development for an automated drilling and filling system on the Regional Turbo Prop fuselage shall be driven by the following key factors: increase of integration, reduction of assembly flow, reduction of assembling costs and increase of automation.
The following processes shall be investigated, among the actual state of art:

1. Automated drilling of composite structure, with particular attention to quality requirements, innovation and high automation level;
2. Automated fastener insertion, with particular attention to the capability to choose the right fastener in terms of length;
3. Automated positioning of the equipment, capability to read, adjust position and inspect scanning the actual position of the sub-structure, computing data through a developed algorithm and adjust the NC program hole pattern.

The equipment shall be installed at Topic Manager's facilities.
For each of the above three processes, the Applicant shall evaluate and propose different solutions in terms of configuration, and for each of them a comparison, in terms of cost, production rate and level of integration. This shall be done in conjunction with the Topic Manager.
A complete technical specification shall be prepared as answer to the above request. It shall include at least:

- trade-off study;
- chosen equipment configuration;
- productivity data;
- process parameters;
- equipment acceptance test proposal.

Task 2 – Equipment design
Equipment shall be designed to fully satisfy the requirements described in this document.

Equipment shall be an integrated system of the three main components: drilling and fastening (sealing and insertion) head, moving equipment and vision, analysis, positioning and alignment system, as described previously.
Also panel handling, moving and clamping features need to be taken into account into the design.
Some (but not limited to) main characteristics of the equipment shall be:

- Capability to work with the geometries described in this document and drawing tolerances;
- Capability to drill holes sided up to 7/16" (11.11 mm) in one pass on composite-composite, composite-aluminum joints. Drilling shall be performed through bonded stack-up. Future extension of application to Aluminum-Aluminum joint shall be possible;
- One Up Assembly process capability: drilling with no contamination (or burrs in case of metals) occurring at the joint interfaces or at the exit of the hole so that part shall not be disassembled for checking, cleaning, deburring, repairing as applicable;
- Holes Automatically checked for Diameter, Countersink and Grip Measurements;
- Application of automated adjustable force with a pneumatic pressure foot (from outside);
- Capability to adjust process parameters depending on the cutting forces;
- Capability for thrust force recording;
- Capability for automated fastener selection and insertion;
- System of fastener sealing for wet installation;
- System for fastener storage and feeding;
- System of coolant for hole drilling;
- Lubricant system for drill bits;
- Peck drill cycle for improved metal chip clearance;
- NC programming;
- Functionality of a 7 axis machine with a System of Rails (see Fig.1 for reference, 7-axis is for reference, number of axis can be higher or lower);
- Capability of part/ hole pattern adaptation through a vision, analysis, re-positioning and alignment system (see Fig.2 for general system architecture);
- Adequate suction system shall be provided for composite dust and metal chips collection;
- Automated Fastener feeding system;
- Automated tool change;
- Capability of moderate load application (approx. 150 kgf);
- Stand/ scaffolding for drill coupon (process development, countersink set up and other) (coupon dimensions = 300x 300mm);
- Holding/ handling Tool for curved panel for pre-acceptance and acceptance tests (curved panel dim. are 1mx1m approx.);
- Flexibility of the proposed solution to application other than fuselage panels will also be considered.
- Cell controller, complete of PC, HD and SW, that must check the status of the complete equipment in real time, record the error message, manage the part programs, change the work parameters, activate/ deactivate auxiliary systems (ex. lubricant system) and manage the maintenance events.
- Remote control system application will be shared with the partner to simplify the use of the cell.

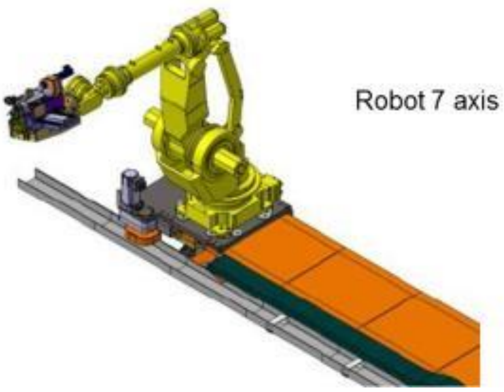


Fig. 9: Illustration of 7 axis robot concept

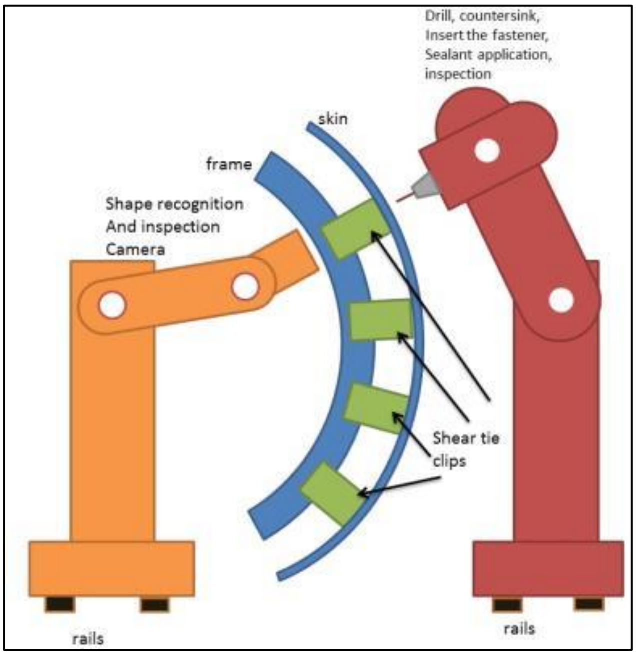


Fig. 10: General system architecture

Task 3 - Test Plan of the three main components and their integration

After design, a Test Plan for each of the three main components shall be produced by the partner (document will require Topic Manager's approval), listing and describing all the tests that have to be conducted to develop the process.

Equipment shall satisfy the requirements listed in this document. In addition, relevant quality/ dimensional requirements applicable to the standard aeronautical practice shall be met.

Test Plan has to take into account all the characteristics requested to the equipment and all the possible combinations of factors. The scope of the Test Plans is to allow a complete verification of the solution individuated during the previous trade-off analysis.

Task 4 - Equipment development and construction

Equipment shall satisfy all design requirements. Tests required by plans shall be conducted during the equipment construction, thus supporting and orienting the development of the automatic equipment.

Task 5 – Pre-acceptance tests

A pre-acceptance phase shall be conducted before equipment shipping to the Topic Manager plant in order to verify technology readiness and conformance to the requested performance level.

Pre-acceptance minimum requirements and relevant quality criteria will be communicated by the Topic Manager.

A dedicated test book shall be prepared by the Applicant (document will require Topic Manager's approval) including functional and manufacturing trials (on flat and curved panels, approx. dimensions of curved panels are 1mx 1m). Tool for holding /handling curved panel shall be designed / assembled by the Applicant.

Outputs of this task shall be:

- process/ equipment set-up for all the different combinations of stack-up (three cases);
- definition (even if preliminary) of the main Key process parameters (including dimensional end item measurements);
- estimated level of hole quality and positioning accuracy using the vision/ analysis/ repositioning system.

After the completion of this task, the machine shall be disassembled and shipped to the Topic Manager's plant. The partner will have complete responsibility of Equipment installation at Topic Manager's plant in terms of required personnel, handling tools, safety cost. The Topic Manager will make available an area for temporary storage of materials and the overhead crane at the area where the machine will be installed.

Task 6 - Equipment Acceptance

An acceptance task, similar but more in depth than pre-acceptance, shall be performed after final installation in the Topic Manager facilities. A Full-size Panel shall be successfully drilled, checked and assembled in order to validate the Equipment capabilities.

Acceptance minimum requirements and relevant quality criteria will be communicated by the Topic Manager.

Outputs of this task shall be:

- final process/equipment set-up for all the different combinations of stack-up;
- complete definition of the main Key process parameters (including dimensional reports on end item performed by the equipment);
- compliance with the requested level of quality and positioning output of the vision/repositioning system;
- NC part program of drilling and assembly of panels (no. 6 panels described in this document);
    - Training for programming (NC), Equipment usage and Maintenance for personnel working at Topic Manager's facilities.

Task 7 - Fuselage Demonstrators Drilling and Fastening

Equipment shall be tested on final planned demonstrator.

The partner shall provide the required support for drilling and assembly operations of no.6 panels as described in this document.

Maintenance and spare parts shall be guaranteed by the partner until the completion of all the activities planned within the ITD that will require use of the equipment (2 full complete demonstrators, 12 panels).

Additional Technical and organizational information is herein reported:
Demonstrator is composed by 6 different stiffened panels:
Max dimension for panel: 3.8m x 3.2m x 1.72m (length x chord x radius);
Min dimension for panel: 3.4m x 2.54m x 1.72m (length x chord x radius);
Figures 3, 4 and 5, below, represent the generic stiffened before frame/ shear tie clips installation, a typical frame configuration (frame + separate shear tie clips) and the generic stiffened after frame/ shear tie clips installation, respectively.

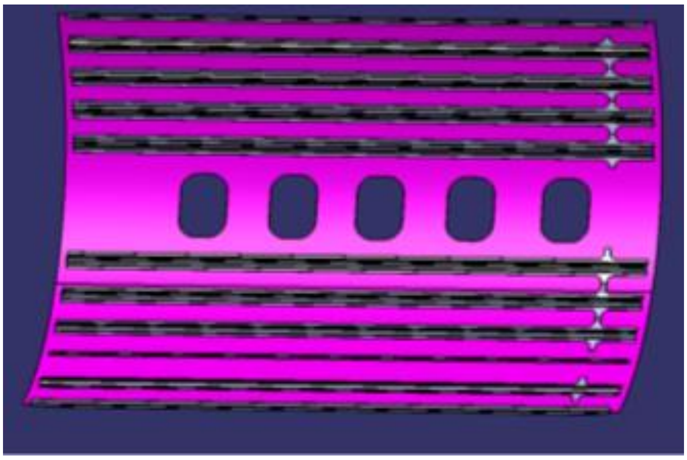


Fig. 11: Generic stiffened before frame/ shear tie clips installation

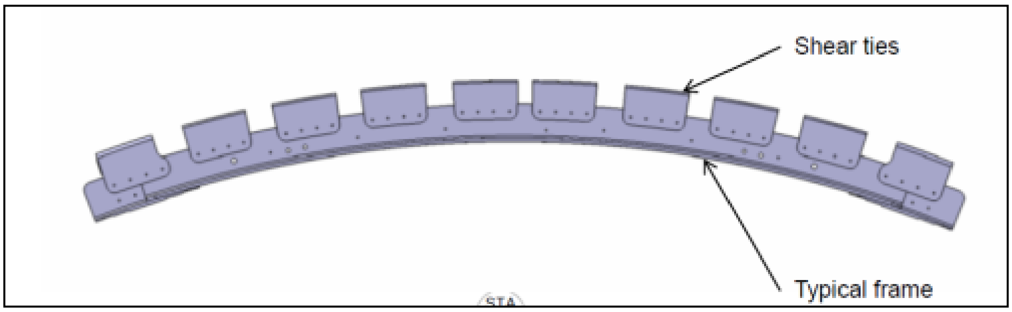


Fig. 12: Typical frame configuration

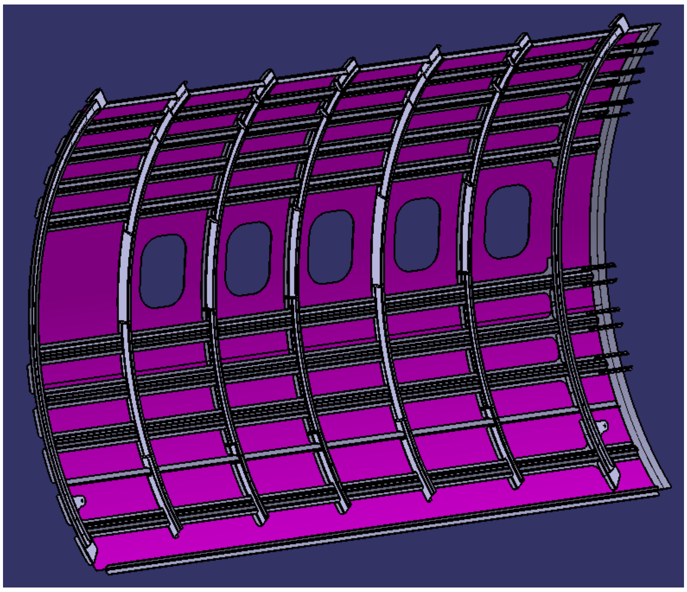


Fig. 13: Generic stiffened after frame/ shear tie clips installation

Panel material (skin): carbon composite.
Shear tie clip material: carbon composite and aluminum.
Productivity time requested: 30 sec. per fastener inserted (floor-to-floor time).
Panel Thickness range: 2-6 mm (skin + stringer pad).
Clip Thickness : 2-4 mm
Hole position tolerance: ±0.2 mm.
Countersink depth repeatability requirement: ±0.025 mm on depth (3σ analysis).
Edge Margin: min 2.5D + 1mm (D= nominal hole size), respect to the clip flange edge (consider hole axis).
Hole size tolerance: [0, +0.076mm].
Max Hole angularity allowed: ± 2°.
Typical fastener system to be considered is represented in Figure 6 (Hi-lok). Collar insertion and installation shall be performed by hand.

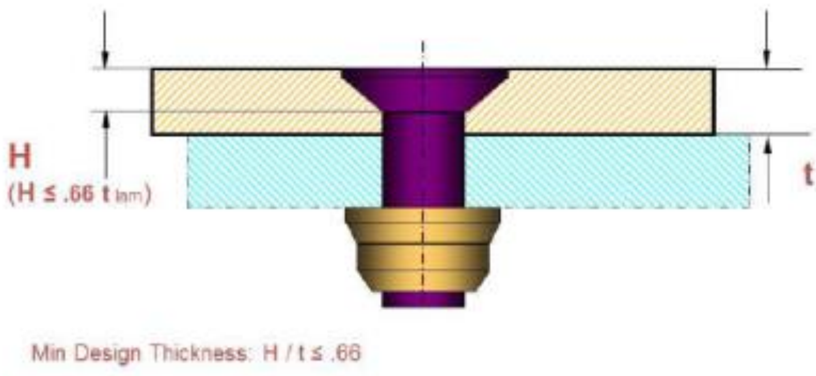


Fig. 14 – Typical fastener system (hi-lok)

Tool used for Panels assembly is composed by an “index tool” for internal side frame positioning, coordinated with an outer side tool that provides end-item panel shape. Inside tool allows Shear tie Clips positioning and preload application for installation using liquid shim between skin and shear-clip.
A schematization of frame tacking process is represented in Fig. 7. Tools described in Fig. 7 are not subject of the Call. This description is provided for an overall description of the environment in which the system is requested to perform.

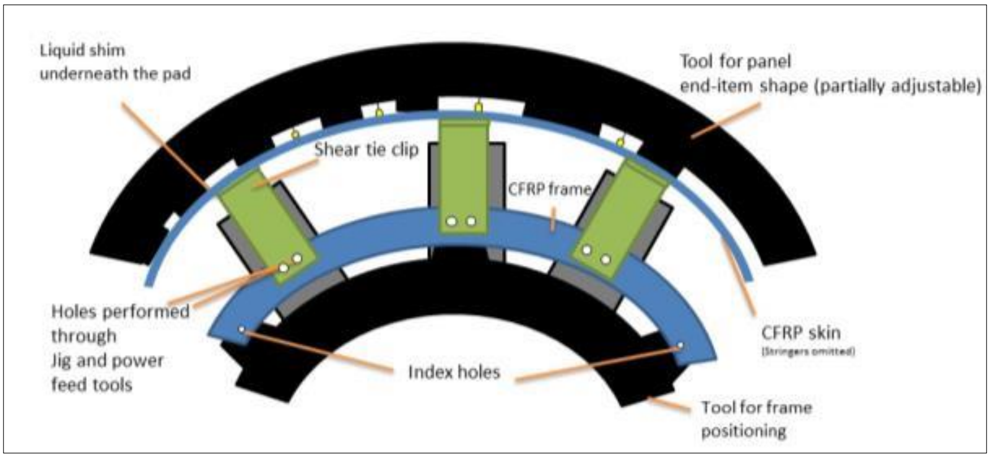


Fig. 15: Frame tacking process schematization

Re-positioning algorithm approach is shown in Fig. 8.

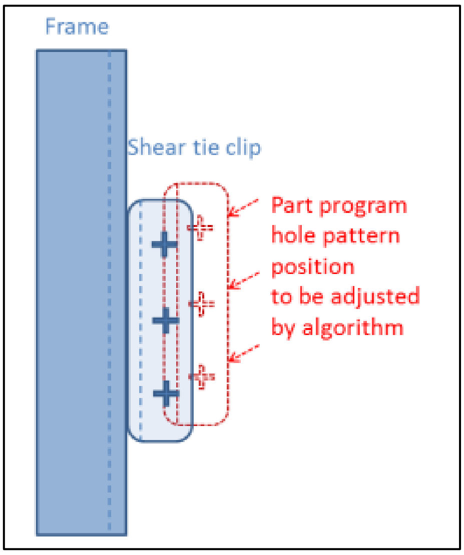


Fig. 16: Re-positioning algorithm

Examples of vision and detection technology features are represented in Fig. 9. Two examples are shown: edge and hole detection (which may be applied to a clip edge and holes for this case of study).

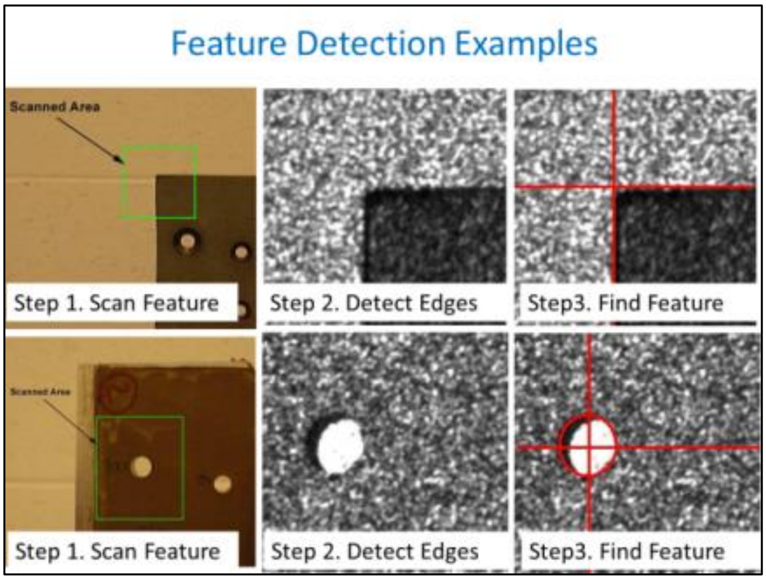


Fig. 17: Vision and detection technology features

The lay-out available for Equipment installation at Topic Manager's plant is herein described:

- Lay-out dimensions are: 5.5m x 4m, provided with overhead crane (5 tons.). The use of overhead crane will be shared with the Topic Manager.
- The installation area will be equipped at Topic Manager's plant with all the supplies requested for Equipment functionality (power, air, vacuum) and foundation (if needed) according to technical specifications provided by the Applicant at the time of M2 (milestone).
- Maximum height of the system will be under 5.5m to prevent interferences with the overhead crane.
- Max floor ground load of the building is 2.000 Kg/m².
- Available building sliding doors dimension is 4m (wide) X 4m (high).

The partner shall provide:

- Lifters and other equipments required for the lifting and handling used for the installation of the system inside the Topic Manager's plant.
- Safety systems, delimitation and cleaning of the yard.
- Safety costs inclusive of partner's workers safety training and documentations.
- Equipment, tools and auxliary materials used for the cell installation.

See Fig. 10 for reference Layout. The area is enlighted in red.

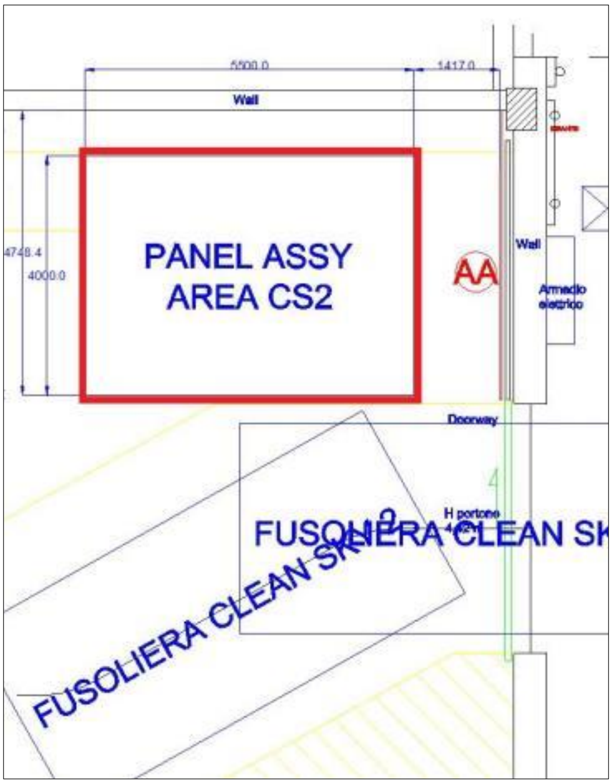


Fig. 18: Reference lay-out

3. Major Deliverables/ Milestones and schedule (estimate)

	Deliverables		
Ref. No.	***Title – Description***	***Type***	***Due Date***
D1.1	Machine Configurations Trade-off Analysis	Report	T0 + 3
D1.2	Machine Technical Specification	Report	T0 + 3
D2.1	Equipment Design: description report	Report	T0 + 6
D2.2	Equipment Design: drawing	Report (Drawing)	T0 + 6
D3.1	Test Plan: drilling head	Report	T0 + 6
D3.2	Test Plan: fastener insertion and sealing tool	Report	T0 + 6
D3.3	Test Plan: moving, vision, re-positioning and inspection system	Report	T0 + 6
D4.1	Test Report	Report	T0 + 18
D4.2	Equipment Construction	Hardware	T0 + 18
D4.3	Part Program	Report (PP)	T0 + 19
D4.4	CN procedure, routines description, maintenance	Report	T0 + 19
D5.1	Pre-Acceptance Test Book	Report	T0 + 18
D5.2	Pre-Acceptance Tests and Report	Hardware + Report	T0 + 20
D6.1	Equipment installation at Topic Manager Plant	Hardware	T0 + 22
D6.2	Acceptance Test Book	Report	T0 + 21

	Deliverables		
Ref. No.	***Title – Description***	***Type***	***Due Date***
D6.3	Part Programs	Report (PP	T0 + 22
D6.4	Acceptance Tests and Report	Report	T0 + 24
D7.1	Final Manufacturing and Cost Assessment Report	Report	T0 + 30

*Types: R=Report, D-Data, HW=Hardware

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M1	Trade-off analysis: description report	Report	T0 + 3
M2	Equipment Design: description report	Report	T0 + 6
M3	Equipment Construction	Hardware	T0 + 18
M4	Equipment installation at Topic Manager Plant	Hardware	T0 + 22
M5	Acceptance Tests and Report	Report	T0 + 24
M6	Final Manufacturing and Cost Assessment Report	Report	T0 + 30

*Types: R=Report, D-Data, HW=Hardware

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

- Skill 1: Proven competence in design and construction of equipment for aeronautical composite components assembly, by a documented experience in participating in actual aeronautical program. This competence shall include a strong knowledge of processes, quality, tooling, part programs for NC machines.
- Skill 2: Proven experience in experimental testing from coupon levels up to aeronautical full scale substructures. Evidence of qualification shall be provided.
- Skill 3: Proven experience in cost estimation at industrial level for aeronautical full scale composite structures.
- Skill 4: Proven experience in vision and inspection technology at industrial level.

5. Abbreviations

WP	Work Package
NC	Numerical Control
A/C	Aircraft
PP	Part Program
PC	Personal Computer
HD	Hard Disk
SW	Software

XVII. Prototype Tooling for subcomponents manufacturing for fuselage

Type of action (RIA or IA)	IA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	WP B-4.3		
Indicative Funding Topic Value (in k€)	350		
Topic Leader	FIDAMC	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	10	**Indicative Start Date**[55]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-AIR-02-50	**Prototype Tooling for subcomponents manufacturing for fuselage**
Short description	
The aim of this Call for Proposal is to develop, design, manufacture and deliver to the Topic Manager facilities, all the prototype subcomponent manufacturing tooling required to manufacture fuselage panel representative of a regional aircraft demonstrator. The development of this tooling shall be innovative in order to implement the best performances in the following fields: Low Cost/ Natural Materials, Eco-design, Energy savings, Manufacturing processes simplification-Production time savings, whilst ensuring that each one of the single parts manufactured with the prototype tooling meets with the Aeronautical quality standards.	

[55] The start date corresponds to actual start date with all legal documents in place.

1. Background

This Call for Proposal is issued as part of Clean Sky 2 Joint Technology Initiative in which several demonstrators will be developed by the industry. The tasks within this project involve components related to the call JTI-CS2-CPW01-AIR-02-03 Advanced technologies for More Affordable Composite Fuselage.
The call will contribute to the activities in Airframe ITD WP B-4.3.6 SHERLOC (Structural HEalth monitoring, manufacturing and Repair technologies for Life management Of Composite fuselage). The main activities within the SHERLOC project are directed towards two main areas:

- Advanced methodologies and technologies for maintenance/repair and NDI/SHM
- Manufacturing and testing for validation and verification

They address in particular the improvement of the current advanced technologies and methodologies with the aim to make them ready for the industrialization phase of a new regional aircraft fuselage.
A key component to be manufactured and tested within SHERLOC is a fuselage panel which is composed of skins, stringers and frames (although the frames will be not part of the call). This component will be sub-assembled with maximum level of integration and reducing assembling work.
Proposed materials to manufacture the parts should be preferably composite suitable for Autoclave processing. The selected technology to manufacture the different fuselage parts will be ATL and FP machines, hot forming process and curing process.
The Partner that will be selected for this Call will be the responsible for developing design, manufacture and deliver to the Topic Manager the tooling set for all single parts needed to manufacture a fuselage panel in agreement with materials, manufacturing processes and technical specifications selected or developed by the Topic Manager.

2. Scope of work

The objective of most of the technologies involved in the Airframe ITD is to reach a maturity level necessary to allow flight testing of demonstrators.
The manufacturing process of the fuselage panel will involve co-curing or co-bonding, where the skin will be laminated in AFP over male tool and later will be transferred to a female tooling for cure. For omegas or T stringer, a flat laminate will be done in ATL machine where the final geometry is achieved with a hot forming process.
The approximate maximum dimensions of the curved stiffened panel will be 5x1.7m and 1.5m radius.
Possible technology challenges: prepreg, ATL/FP machine, hot forming process and co-curing in autoclave at temperature 180°C and 9 bar pressure.

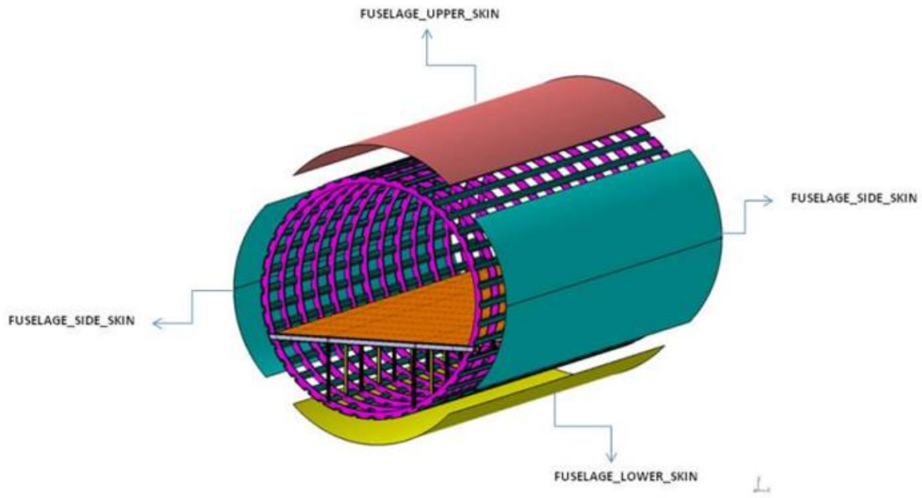


Figure 10: Fuselage components

The final requirements, including the manufacturing process of each parts, and features needed for the Prototype Manufacturing tooling will be provided by the Topic Manager at the beginning of the project with the delivery to the Partner of the Technical Specification for the Tooling.
The innovative character of the manufacturing tooling developed in this CfP will be reflected in the materials employed, the interaction between the expansion coefficient and thermal conductivity of the different materials and interaction between the internal modules and the rest of the mould. In order to reduce costs the possibility of using those modules during the forming process of the preform will be studied.
The materials selected will be optimized to reduce the thermal inertia and to improve their thermal conductivity. Their manufacturability will also be studied in order to ease the modification of the mould due to new requirements identified during the specimen manufacturing (e.g. welding processes or surface finish improvement).
The use of new materials can be proposed as long as the technology is above TRL4-5. The final design has to be accepted by the Topic Manager.

The proposal must include at least the following tools.

- Fiber Placement Tool.
- Female curing Tool.
- Caul plates.
- Hot Forming Tool.
- Stringer location Tool.

The Partner will be supported by the Topic Manager during the Prototype Tooling Design and Manufacturing phases with the following tasks:

- Design Trade-off Studies/Conceptual Studies.
- Material and Production Trade-off Studies for Production process selection.

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 manufacture Prototype Tooling for fuselage 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 manufacture Prototype tooling that will assure the demanded quality of each part in accordance with the Technical Specifications and the Aeronautical Quality Standards.
- Generate a tooling documentation in agreement with the Topic Manager 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 Topic Manager. Work with geometrical verification means e.g. laser tracker.
- Deliver the Prototype Tooling set for manufacturing to the Topic Manager facilities in appropriate transportation means.
- Support the set up in the Topic Manager premises.
- Follow up of the works performed by the Topic Manager until the end of the manufacture of the flightworthy demonstrator.
- Define Prototype Tooling that will simplify the single part manufacturing process when compared with current tooling systems.
- Endeavour, in the Prototype Tooling Design, to incorporate innovative and low cost concepts in terms of Materials and Design processes.
- Identify and report at least the following information: RC (Recurrent Cost), weight (if applicable), materials, manufacturing procedures, LCA data, etc., always comparing the developed tooling solution to the current solutions applied in industry.

3. Major deliverables/ Milestones and schedule (estimate)

According to the preliminary planning of the overall programme and to achieve the related milestones, an estimate of dates for deliverables and tasks of the project are indicated below.

Tasks		
Ref. No.	**Title - Description**	**Due Date**
T1	Development and detail design of all tooling needed to manufacture fuselage panel	T0+3
T2	Manufacture of the tooling	T0+8
T3	Validation of the tooling as agreed with the Topic Manager (dimensional, air tightness, etc.)	T0+9
T4	Delivery of the manufacturing tooling to the Topic Manager facilities and support set up	T0+10

Table 1 Partner tasks

The prototype tooling that will be delivered shall:

- Incorporate innovative and low cost tooling, in order to achieve the manufacturing processes in just one shot of highly integrated CFRP parts, in order to save energy and manufacturing times needed for manufacturing.
- Implement new or innovative materials for prototype moulding manufacturing but always taking into account the earlier requirement concerning TRL level
- Achieve Surface Quality satisfying the standards of the Aeronautic Industry.

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Tradeoffs report: - *Design trade-offs based on Topic Manager proposed concepts. Manufacturing approaches for any proposed solution.* - *Materials, RC, Weight, LCA….* - *Thermal simulation Report*	*Report*	T0+2
D2	Advance preform system: - *Prototype Tooling ready to produce parts (including heating and control system-if necessary)* - *Auxiliary tooling needed for the preforms.* - *Quality inspection reports-CoC* - *Tooling Manufacturing Report* *Prototype Tooling Maintenance and Working or manufacturing Orders.*	*Toolings* *Report* *Drawings* *Hardware*	T0+8
D3	Design documents, 3D models CATIA V5 R21, Tooling Manufacturing reports, etc. (The same as Deliverable nº1&2) for possible Tooling modifications during follow up phase.	*Toolings* *Report* *Drawings* *Hardware*	T0+9
D4	Final report: Conclusions and lesson learned	*Report*	T0+10

Table 2: Main Deliverables

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

(M) – Mandatory; (A) – Appreciated

- Experience in design and manufacturing of tooling for structures in conventional composite materials and innovative metallic components. (M)
- Design and analysis tools of the aeronautical industry: i.e. CATIA V5 R21 (M), NASTRAN (M), VPM. (M)
- Experience in management, coordination and development of technological (Aeronautical) programs. (M)
- Proven experience in collaborating with aeronautical companies. (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)
- 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 ATL/FP, hot forming and autoclave technologies. (M)
- Advanced Non Destructive Inspection (NDI) and tooling inspection such as (A):
    - Dimensional and shaping inspections.
    - Morphology studies of materials-if needed.
    - Ultrasonic inspection capabilities.
    - Contactless dimensional inspection systems.
- Simulation and Analysis of Tolerances and PKC/AKC/MKC (Product, Assembly and Manufacturing Key Characteristics). (A)

5. Clean Sky 2 – Engines ITD

I. Bearing chamber in hot environment

Type of action (RIA or IA)	RIA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP2 – Ultra High Propulsive Efficiency		
Indicative Funding Topic Value (in k€)	1700		
Topic Leader	Safran	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[56]	Q1 2018

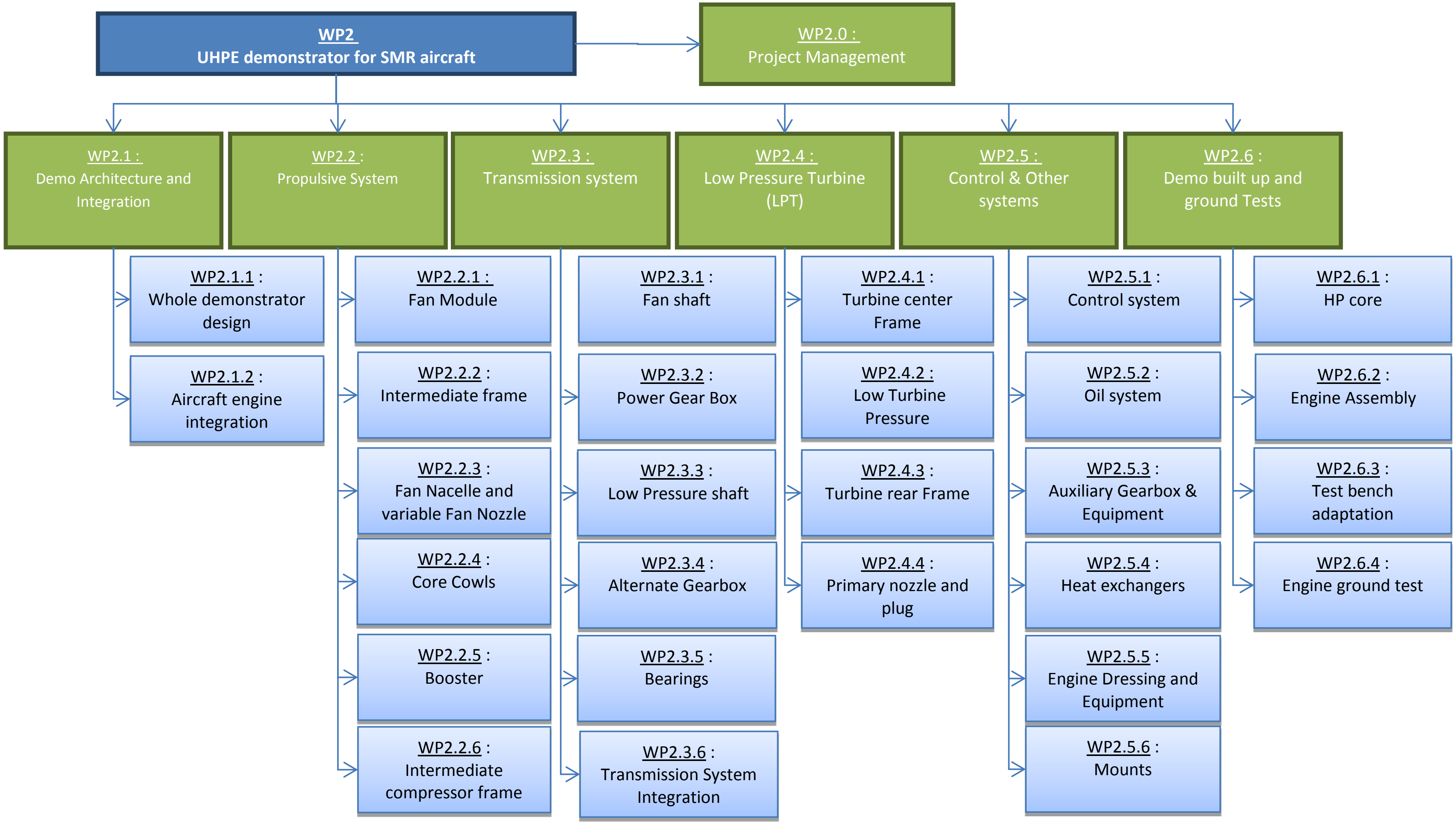
Topic Identification Code	**Topic Title**
JTI-CS2-2017-CFP06-ENG-01-15	Bearing chamber in hot environment
Short description	
Improvement of design of compact bearing chamber in hot environment. Determine influence of key parameters on heat rejections and heat transfer.	

[56] 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.

The UHPE demonstrator will have completely new LP spool including 2 bearing chambers.
The design of more fuel efficient engines leads to more bearings which have to be integrated in compact sumps in a hot environment. In order to optimize the overall system performance, the heat rejections have to be limited and well predicted and the air consumption has to be minimized.
The breakdown in this WP2 is the following:


WP2
UHPE demonstrator for SMR aircraft
WP2.0 :
Project Management
WP2.1 :
Demo Architecture and Integration
WP2.2 :
Propulsive System
WP2.3 :
Transmission system
WP2.4 :
Low Pressure Turbine (LPT)
WP2.5 :
Control & Other systems
WP2.6 :
Demo built up and ground Tests
WP2.1.1 :
Whole demonstrator design
WP2.1.2 :
Aircraft engine integration
WP2.2.1 :
Fan Module
WP2.2.2 :
Intermediate frame
WP2.2.3 :
Fan Nacelle and variable Fan Nozzle
WP2.2.4 :
Core Cowls
WP2.2.5 :
Booster
WP2.2.6 :
Intermediate compressor frame
WP2.3.1 :
Fan shaft
WP2.3.2 :
Power Gear Box
WP2.3.3 :
Low Pressure shaft
WP2.3.4 :
Alternate Gearbox
WP2.3.5 :
Bearings
WP2.3.6 :
Transmission System Integration
WP2.4.1 :
Turbine center Frame
WP2.4.2 :
Low Turbine Pressure
WP2.4.3 :
Turbine rear Frame
WP2.4.4 :
Primary nozzle and plug
WP2.5.1 :
Control system
WP2.5.2 :
Oil system
WP2.5.3 :
Auxiliary Gearbox & Equipment
WP2.5.4 :
Heat exchangers
WP2.5.5 :
Engine Dressing and Equipment
WP2.5.6 :
Mounts
WP2.6.1 :
HP core
WP2.6.2 :
Engine Assembly
WP2.6.3 :
Test bench adaptation
WP2.6.4 :
Engine ground test

2. Scope of work

Tasks		
Ref. No.	***Title – Description***	***Due Date***
Task 1	Definition of the test matrix and needed instrumentation	T0 + 9 month
Task 2	Definition of the test vehicle and associated test bench systems	T0 + 9 month
Task 3	Design / manufacturing of test vehicle and test bench systems	T0 + 20 month
Task 4	Thermal and fluid model of the bearing chamber	T0 + 20 month
Task 5	Test campaign	T0 + 24 month
Task 6	Analysis of test data and adapted methodology	T0 + 36 month

Task 1

Task 1 and 2 will be performed in parallel. Task 1 will lead to the definition of the test matrix and the range of the key parameters to be scanned. Therefore, this task will defines the specification of the test vehicle and test bench systems of Task 2.

The key parameters to be scanned are:

- Rotor speed
- Oil temperature
- Oil flow
- Oil distribution in the bearing chamber and air/oil mixture
- Temperature of the bearing chamber environment (metal temperature of the stub shaft, air temperature)
- Air flow, pressure
- Wall rugosity

The test conditions will be defined in order to cover representative conditions of an engine and generate sufficient data in order to understand the heat transfer phenomena. The range will be based on typical engine running conditions supplied by the topic leader and sufficient test points will be run in order to get detailed understanding of the heat transfer. The typical test matrix will lead to about 100 running conditions.

The needed instrumentation has to be defined in order to capture the heat transfer in the bearing chamber in function of the variation of the key parameters. Therefore the instrumentation will be mainly composed of fluid and metal temperature in the bearing chamber. The sensors' location will be chosen consistent with the needs for model matching (model from Task 4) and understanding of the fluids' behavior and heat transfers. State of the Art sensor for industrial applications shall be used (typical precision of 0.3% of full scale).

Task 2

This Task aims at defining the rig test of the bearing chamber and its associated systems compliant with the specifications defined in Task 1. The studied bearing chamber will be of a representative design for an aircraft engine and based on a geometry supplied by the topic leader. The bearing will be supplied by the topic leader. The test vehicle and the associated test rig systems will be of the partner's responsibility.

During this task, the following interfaces and schemes will be defined

- Mechanical
- Functional (fluid circuits, electrical interfaces)
- Interfaces to the drive system

Task 3

Based on the agreed definition of the test rig and its associated systems, this Task includes the design and manufacturing work of the test vehicle and the associated systems (air, oil, heating and cooling systems, drive system, controls, instrumentation …). This work will be done by the partner.

The design will enable the integration of a representative bearing chamber in a test rig assembly including the systems capable to conduct the variation of the test parameters defined in the test matrix from Task 1.

The instrumentation will be integrated in order to be consistent with the modelling activity (task 4) and enabling the understanding of the heat transfer phenomena in the bearing chamber. Therefore, the location of the sensors (mainly temperature probes for fluid and metal temperature) will be based on key zones from modelling results (from Task 4). The type and precision of the sensors will be finalized, and the sensors integrated in the test vehicle.

The parts will be defined, manufactured, instrumented and assembled to the complete test vehicle by the partner. The vehicle will be installed in the test bench and connected to the fluid and electrical systems and data acquisition and control system.

At the end of this work package, the complete test assembly will be commissioned and instrumentation sensors calibrated.

Task 4

In this Task, the bearing chamber will be modelled in its environment in the test rig by the partner.

The model will permit to predict the fluid circulation (air, oil) in the bearing chamber and the heat transfers (solid to fluids, power generated by bearings, radiation) in the different zones of the bearing chamber. The solid will be modelled by a Finite Element Modelled linked to a Fluid Zone Model for the heat exchange to the fluids (oil, air and air/oil mixture). CFD calculation of the Fluids could be performed in order to improve understanding of the fluids' circulation. The focus shall be put on understanding the heat transfer to the fluids depending on the key parameters and the fluids circulation in order to characterize the heat rejection of the bearing chamber.

Task 5

In this Task, the agreed test matrix will be run and the data acquired by the partner.

Task 6

In this Task, the data of Task 5 will be analyzed and compared to the prediction of Task 4 in order to achieve a complete understanding of the physical phenomena in the bearing chamber. The differences will be analyzed and new methods set up in order to acquire a methodology able to predict the phenomena in a bearing chamber in hot and compact environment.

The main deliverable is a methodology to calculate the heat transfer coefficient and the fluid flows (repartition) for different zones in the bearing chamber depending on the key parameters.

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type (*)***	***Due Date***
D1	*Test definition* Test matrix, test parameters, type and precision of instrumentation	RM	T0 + 9 month
D2	*Concept description* Concept of test vehicle Interface and system schemes	RM	T0 + 9 month
D3	*Detailed description* Detailed description of test vehicle, test bench and systems	R	T0 + 15 month
D4	*Test commissioning* Report of commissioning of the test rig and data acquisition system	R	T0 + 20 month
D5	*Model and test prediction* Description of the model and the used formulas and delivery of the model Prediction of the temperatures in the bearing chamber and the heat to oil load of the conditions defined in the test matrix	R and D	T0 + 20 month
D6	*Test report* Description of test conditions and delivery of associated test data	R and D	T0 + 24 month
D7	*Analysis of test data and adapted methodology* Detailed analysis of the test data, comparison with prediction by the model. Analysis of the differences. Adaptation and delivery of the modelling and methodology to model the heat transfer phenomena.	R and D	T0 + 36 month

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
MS 1	*End of Concept Phase*		T0 + 9 month
MS 2	*Test bench commissioning*		T0 + 20 month
MS 3	*Delivery of prediction results*		T0 + 20 month
MS 4	*Delivery of the modelling and the adapted methodology*		T0 + 36 month

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

- Proven competence in design, manufacturing, instrumentation of complex component rig tests and the associated systems (air, oil, control)
- Availability of test benches to support test campaign
- Proven competence in complex thermal modelling and heat transfer analysis
- Proven competence in test analysis
- English language

II. Torque measurement in turbofan

Type of action (RIA or IA)	IA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP2 – Ultra High Propulsive Efficiency		
Indicative Funding Topic Value (in k€)	1000		
Topic Leader	Safran	Type of Agreement	Implementation Agreement
Duration of the action (in Months)	30	Indicative Start Date[57]	Q1 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CFP06-ENG-01-16	Torque measurement in turbofan
Short description	
Measuring shaft torque is key to understand aircraft engine behavior. Nevertheless space around engine shaft is limited and current torquemeters or telemetry systems cannot be easily implemented. The aim of this CFP is to develop a torque measurement system without telemetry for engine testbench (possibility to use on a flying test bench would be an asset but is not mandatory it will not be embedded on a commercial flight)	

1. Background

The aim of the CfP is to develop a complete system to measure torque on an aircraft engine during tests (it will not be embedded on a commercial flight but could be used on flying test bench).

Measuring shaft torque is key to understand engine behavior and particularly for shaft and gearbox. Commonly, torque can be measured using:

- Deformation
- Phase shift

There is no preference between possible solutions in this CfP to develop the torque measurement system.

This system shall measure static torque and its high frequency oscillations (> 10 kHz) with 0.1% precision under 35 000 N.m. and 1% between 50 000 and 90 000 N.m.

[57] The start date corresponds to actual start date with all legal documents in place.

It shall be designed with the following constraints:

- Environment
  - Temperature between -40 and 400°C (for the sensing element depending on its location)
  - Electronics can be installed in cooler environment: on cold zones on the engine, temperature can reach 150°C or the system can be installed outside the engine if precision and integration is OK.
  - Oiled environment or oil mist/fog
  - Vibration and Acceleration : on its resonance frequencies, the system shall resist to 20g of acceleration at least (ideally 50g)
- Integration
  - The sensor shall not be installed on rotary parts
  - It could be acceptable to customize the surface of the shaft (paint, sticker, laser marking, or anything else on the surface only) if necessary
  - Reduced size compatible with limited space available around the shaft.
  - The effect of wire routing shall be limited
  - Air gap (between 1 mm and 10 mm – it will be confirmed during the project and strongly depends on the integration and proposed solution)
  - Life time of the sensor shall be higher than 100h and ideally 1000h

2. Scope of work

The aim of the CfP is to develop a complete system to measure shaft torque.

The system shall include:

- Sensing element(s)
- Conditionning
- Routing
- Acquisition system is not mandatory but the output of the system shall be analogic (Volts)

The partner will:

- Make a scorecard of possible solutions and identify the best system to answer the need considering technical constraints and integration in an aircraft engine
- develop and build this system
- prototype it on its own test bench
- improve the system considering prototype results and taking into account integration problems
- deliver a torque measurement system for the test on an aircraft engine and support the test on an aircraft engine , especially in terms of hardware spares , refurbishment of the torque measurement system , set up of this system before and during the test ; the objective of this test is to prove the system is efficient and will not damage the engine .

Nota: integration problems on the aircraft engine shall not be under-estimated and the candidate shall explain how he will manage integration of this system on an aircraft engine

Tasks		
Ref. No.	***Title – Description***	***Due Date***
Task 0	*Progress Reporting & Reviews* • Quarterly progress written reports 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.	Continuously
1	*Preliminary study* The partner shall analyse project needs and constraints and propose solutions.	T0 + 12 months
Task 2	*Test plan* The partner shall detail how he will test its design and its specifications answer the needs	T0 + 13months
Task 4	*Prototyping* The partner shall build a prototype and test it on a lab tests bench (not provided by Safran Aircraft Engines)	T0 + 18 months
Task 6	*Improvements and integration* The partner shall improve its system considering prototype tests results. He shall consider the system but also its integration on the engine	T0 + 24 months

Task 7	*Test of the system on an aircraft engine* The partner shall provide a functional system that will be integrated and tested by Safran Aircraft Engines. The partner shall support the test on an aircraft engine for a period up to 4 weeks.	T0 + 26 months

Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type (*)***	***Due Date***
D1	*Management plan*	R	T0 + 1 months
D2	*State of the Art*	R	T0 + 1 months
D3	*Risk Management plan*	R and RM	T0 + 4 months
D4	*Scorecard of solutions*	R	T0+8months
D5	*Preliminary design and specifications*	R and RM	T0 + 12 months
D6	*Test plan*	R	T0 + 13 months
D7	*Delivery of the Prototype*	RM	T0 + 16 months
D8	*Prototype test report*	R	T0 + 18 months
D9	*Final design and specifications*	R and RM	T0 + 24 months
D11	*Delivery of the Final system*	D + RM	T0 + 26 months
D12	*Final report and synthesis*	R+ RM	T0 + 30 months

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
MS 1	*Risk management plan review*	RM	T0 + 4 months
MS 2	*Preliminary design review*	RM	T0 + 12 months
MS 3	*Prototype review*	RM	T0 + 16 months
MS 4	*Final design review*	RM	T0 + 24 months
MS 5	*Final system review*	RM	T0 + 26 months
MS 6	*Final review*	RM	T0 + 30 months

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

- Experience in measurements is mandatory

- Experience in torque measurement is an asset
- Experience with engines is an asset
- Ability to test the prototype or to make it done
- Qualification for aeronautical instrumentation design and product
- English language is mandatory

III. Advanced turbine system performance improvement through dual-spool rig tests

Type of action (RIA or IA)	IA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP 2		
Indicative Funding Topic Value (in k€)	1100		
Topic Leader	GE	Type of Agreement	Implementation Agreement
Duration of the action (in Months)	36	Indicative Start Date[58]	Q1 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CFP06-ENG-01-17	Advanced turbine system performance improvement through dual-spool rig tests
Short description	
Dual-spool turbine rig test to support the maturation of the turbine vane frame (TVF) aerodynamic design for UHPE architectures, including the detailed system (HPT, TVF, LPT) and component performance results to be used in trade studies. Innovative instrumentation approaches including unsteady data acquisition and optical access are needed to quantify and visualize the complex aerodynamic component interactions under engine-representative flow conditions.	

[58] The start date corresponds to actual start date with all legal documents in place.

1. Background

Through Clean Sky 2, GE Germany (GEDE) are developing and validating an optimised design of the turbine vane frame (TVF) for the Ultra High Propulsive Efficiency (UHPE) commercial aircraft engine architecture.

Within the timescales of the Clean Sky 2 program, the UHPE engine will provide significant steps towards the reductions in fuel burn, emissions, and perceived noise targeted by the ACARE 2035 environmental goals for the aviation sector (75% reduction in CO2 emissions, a 90% reduction in NOx emissions and a 65% reduction of the perceived noise compared to a reference of the year 2000). The Ultra High Propulsive Efficiency (UHPE) engine concept requires the development of new technologies for geared aero engines planned to be introduced into the market around 2025.

Geared turbofan architectures such as the UHPE offer significant engine efficiency benefits by allowing the fan and low-pressure turbine (LPT) to rotate at different speeds. This approach enables increased bypass ratios (larger-diameter fans at reduced rotational speed) and lighter, faster, and more efficient LPT configurations compared to traditional turbofan engines. In geared engine architectures featuring a high-speed LPT, novel designs for the turbine intercase are required. The turbine intercase is located between the high-pressure turbine (HPT) and the LPT. The turbine intercase both guides the working fluid into the LPT and also carries structural loads, passes cooling flows from the compressor to the turbine stages, houses piping for secondary and auxiliary systems, e.g. the oil supply, and serves as interfaces for aft mounted systems and sealing.

Recent developments aim at an integrated turbine intercase solution, the so-called Turbine Vane Frame (TVF). A TVF not only features a conventional strut and hub box, i.e. to primarily carry structural loads and housing of tubes, but also utilises its struts as vanes to turn the flow for achieving optimal LPT inlet conditions. Hence, the TVF concept allows for replacing the downstream LPT inlet guide vanes while reducing both weight and length of the engine's turbine and, thus, of the overall engine.

The TVF developed by the GEDE in Clean Sky 2 will be one of the main enablers for the next generation, high-efficiency turbofans. The first application of such engine class will be mid-range, single aisle aircraft, a market currently dominated by the CFM56 and LEAP products. The development of advanced TVF technology aims at strengthening European design capabilities in one key component for future engine architectures.

The TVF's direct contribution to an engine's overall fuel efficiency can be measured firstly by the aerodynamic pressure losses created in the TVF duct while guiding the flow from the HPT to the LPT and, secondly, by the resultant weight and geometric dimensions of the TVF component. The aerodynamic performance of the TVF is strongly influenced by both the inlet conditions (provided by the HPT) and the exit conditions (imposed by the LPT rotor). The specific design of one of these components is known to have direct consequences on the performance of the other components. A dual-spool turbine test effort is needed to demonstrate the performance of both the HPT/TVF/LPT system as well as the breakdown of the component performance levels. The results will be leveraged to validate the

TVF aerodynamic design tools and design approach and to determine performance trades between the components of the HPT/TVF/LPT system. Detailed steady and unsteady data acquisition at multiple streamwise locations, over radial and circumferential sectors is needed to quantify the system and component performance, thus continuous rig operation capability is needed. Detailed unsteady diagnostics are particularly critical to leverage the test data for the validation of novel high-fidelity simulation tools targeted at improving the TVF design process and advancing TVF performance prediction capabilities. A notional layout of the planned dual-spool rig flowpath including blade row definition and main measurement plane locations is illustrated in Fig. 1. The learnings out of the test effort will directly impact the TVF aerodynamic design definition for next-generation turbofans.

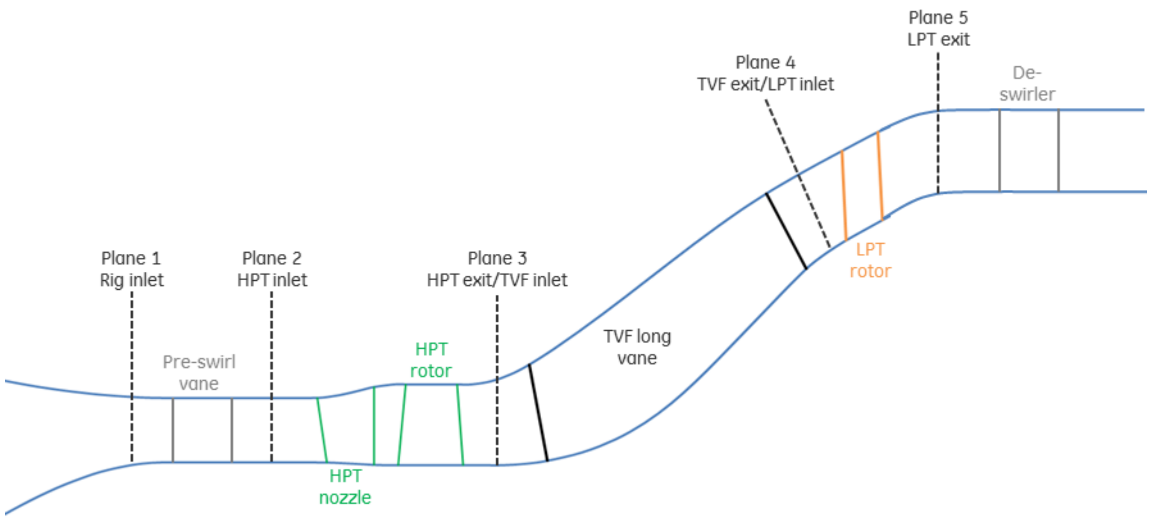


Figure 1. Notional dual-spool rig layout with six blade rows to be simulated and location of main measurement planes 1-5.

The work intended to be covered by the partner in this project includes the support of the test preparations, the assembly of the test vehicle and its installation into a test facility capable of providing continuous engine-relevant flow conditions, the execution of the tests, and the post-processing of the test data.

The successful partner is expected to demonstrate a proven capability in delivering complex dual-spool turbine rigs with engine-representative component definitions (including an HPT with purge flows and relevant tip gap settings) and high-fidelity measurements under a variety of engine-relevant flow conditions (including variations in turbine speed, purge flow, and rig inlet and exhaust operating conditions). In addition, the partner must demonstrate the ability to apply complex data post-processing techniques and provide the test outcomes in a structured manner with clear statements on uncertainty. A work package structure definition to support the tasks outlined above is proposed in the following section.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
WP 1	Test 1 preparations – instrumentation, data acquisition, SAS	T0 + 4 months
WP 2	Test 1 rig assembly and commissioning	T0 + 6 months
WP 3	Test 1 execution	T0 + 10 months
WP 4	Post-processing of test 1 measurement data	T0 + 13 months
WP 5	Test 2 preparations – instrumentation, data acquisition, SAS	T0 + 17 months
WP 6	Test 2 rig assembly and commissioning	T0 + 20 months
WP 7	Test 2 execution	T0 + 24 months
WP 8	Test 1 and 2 data comparison	T0 + 36 months

The main objective of this project is to execute a rig test programme for a TVF aerodynamic design, coupled with an upstream HPT stage and downstream LPT blade, in a flow environment representative of future geared civil turbofan aero-engine applications. The aerodynamic performance of the TVF affected by both the upstream HPT and downstream LPT blade. This test programme aims to deliver both the HPT/TVF/LPT system performance as well as the breakdown of the component performance levels.

Two main test campaigns are planned, as outlined in Fig. 2. In the first test, a baseline TVF configuration is studied. The aerodynamic design of this TVF is based on both design space exploration studies and static TVF cascade testing carried in other GEDE work packages in the Clean Sky 2 programme. GEDE will design and manufacture the hardware for the test vehicle, consisting of six blade rows as sketched in Fig. 1. The partner is then tasked with assembling the test vehicle in an existing rig, setting up and connecting all required instrumentation, data acquisition, and secondary air systems, executing the test, and post-processing the acquired test data.

In the design of the TVF module, the interaction with the HPT and LPT rotor will be accounted for. In order to leverage the test data to guide the TVF aerodynamic design for future UHPE engine architectures, it is critical that engine-relevant TVF inlet and exit flow conditions are simulated. The TVF inlet flow is driven by the HPT aerodynamic design characteristics including secondary flow effects caused by tip leakage and purge flows. Since the performance of any HPT-LPT transition duct is impacted by the level of these secondary flow effects, a variation of HPT tip gap and purge flow levels is planned as part of the test matrix. Recent GEDE-led tests have used interchangeable rotor shroud rings of different thickness (integrated in the rotor casing) to simulate different HPT rotor clearance settings. A similar approach to study the TVF (and LPT blade) sensitivity to HPT rotor tip gap variations is planned on this project. GEDE will provide multiple shroud rings and the partner is tasked with changing these rings during the test campaign. An example of a recent GEDE test of an HPT followed by an HPT-LPT transition duct with simulated HPT purge flows and HPT clearance measurements is shown in Fig. 3. A similar setup is envisaged on the HPT side for the tests in this project.

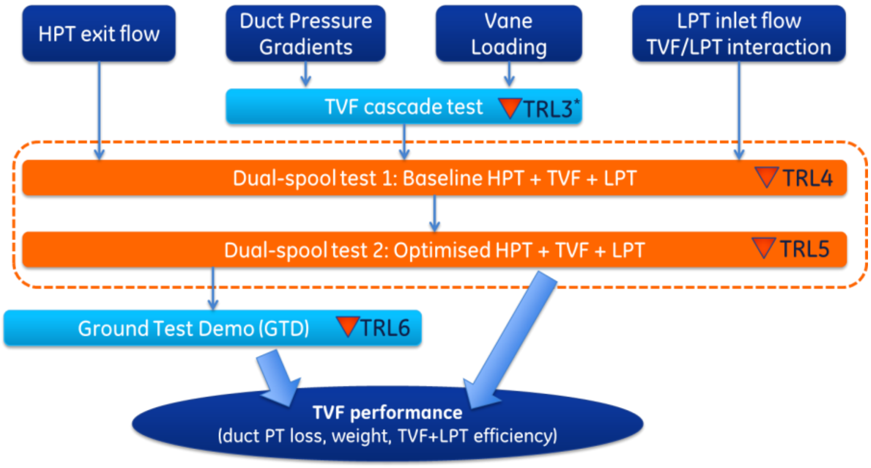


Figure 2. Importance of dual-spool test efforts for demonstrating advanced turbine vane frame aerodynamic technology, validating optimised aerodynamic design, and defining design guidelines for low-loss turbine vane frames in future engine definitions.

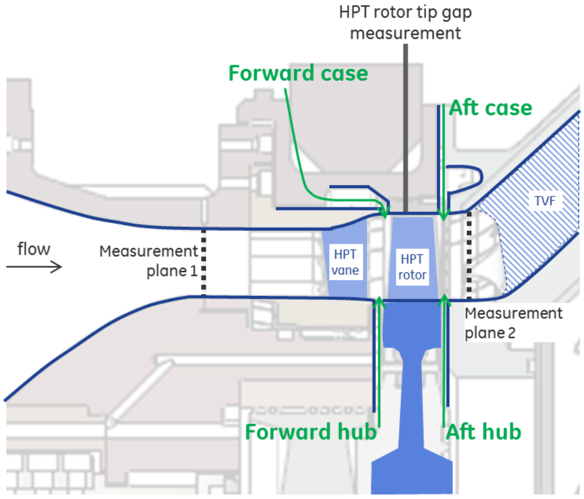


Figure 3. Example of recent GEDE high-pressure turbine rig design including provisions for four HPT purge flows and holes for HPT rotor tip gap clearanceometer probes.

In addition to the TVF inlet flow characteristics, the aerodynamic losses in a TVF duct are governed by the Mach number level and the amount of flow turning through the vanes. Both the exit Mach number and flow angle distribution are influenced by the design of the LPT, thus an engine-representative LPT rotor is installed downstream of the TVF, including the purge flow on the forward hub side of the rotor.

Both the interaction of the HPT with the TVF and the interaction of the TVF with the LPT are heavily impacted by unsteady flow mechanisms. To capture these mechanisms, determine their importance for the TVF aerodynamic performance, and validate design tools, advanced unsteady data acquisiton techniques are planned (e.g. by using fast-response aerodynamic pressure or hotwire probes). In addition, optical access through the TVF casing could be implemented to allow for more detailed studies of the flow behavior and corresponding loss generation mechanisms. While two- or three-dimensional data acquired through advanced optical measurement techniques would enhance the outcomes of this project (in addition to new insight into the TVF aerodynamics, this type of data would also be leveraged for validating novel high-fidelity CFD developed by GEDE in Clean Sky 2), optical access is not a necessary requirement to be met by the successful partner. The main project objectives can be achieved without data from optical instrumentation. Finally, a telemetry system may be installed on the LPT rotor to directly assess the impact of the TVF exit flow not only on the LPT aerodynamic but also on the aero-elastic performance.

After the data acquisition, the test results are post-processed by the partner and the outcomes of the first test campaign will be leveraged in the detailed aerodynamic design of a second test vehicle with new HPT and TVF. The aerodynamic and mechanical definition as well as the hardware procurement and manufacturing will again be carried out by GEDE. The second test campaign targets the validation of an optimised HPT/TVF/LPT system, with the test requirements and test matrix largely identical to the first test programme such that back-to-back comparison of the first and second TVF and overall system designs are possible. The combination of both test campaigns will provide demonstration of the TVF aerodynamic technology up to a maturity level of TRL 5.

Eight separate work packages (WP) have been defined to enable the successful execution of this project. WPs 1-4 cover the first test campaign, WPs 5-8 focus on the second test effort.

WP 1 – Test 1 Preparations

This work package covers all aspects of test preparations needed to be carried out at the partner's test facility. GEDE will provide all test vehicle hardware, where possible in assembled modules, such as e.g. the HPT rotor assembly (disk with assembled blades, spinning completed), the LPT rotor assembly, or the TVF assembly (TVF inner and outer cases with Aerodynamic fairings in between). The interfaces between the test vehicle hardware and the test facility must be jointly defined by GEDE and the successful partner.

The test objectives will also be provided by GEDE and the instrumentation plan required for achieving these test objectives must be defined in close collaboration between GEDE and the partner. WP 1 includes instrumenting the test vehicle hardware based on the instrumentation plan. In addition, data acquisition systems will be set up. Finally, the SAS needed to deliver purge flows to the HPT and LPT will be prepared such that the purge flow delivery pipes can be connected to the test vehicle during the rig assembly effort.

WP 2 – Test 1 Rig Assembly and Commissioning

In this work package, the test 1 hardware delivered by GEDE will be assembled at the partner's facility, connected to the supporting instrumentation/data acquisition systems, and to the SAS. Calibration of all instrumentation before (and after) the tests is needed to ensure the reliability of the test results. The rig assembly also includes final rotor balancing and alignment of rotor and casings on both the high-pressure and low-pressure spools. After the rig assembly is completed, all aspects related to commissioning of the rig will have to be carried out.

WP 3 – Test 1 Execution

This work package covers the rig operation to complete the first test campaign in the project and the generation of all test data. Test requirements, operating conditions, safety and alert limits, and test schedule will be jointly defined by GEDE and the partner during the test preparation phase. Variations of TVF inlet conditions (e.g. by varying the HPT exit flow angle, HPT clearance setting, or HPT purge flow levels) are planned in the first measurement campaign. In addition, the LPT rotor will be run at design and off-design conditions.

WP 4 – Post-Processing of Test 1 Measurement Data

Work package 4 deals with post-processing of all test data acquired during the first measurement campaign. Post-processing techniques are expected to be agreed on with GEDE. Any post-processed results must include an uncertainty statement taking into account contributions to the overall uncertainty from rig operation, measurement and probe working principle, and data acquisition system.

WP 5 – Test 2 Preparations

This work package includes all tasks needed to prepare for the second test campaign. Again, all test vehicle hardware will be provided be GEDE. Part of the hardware from the first test campaign such as supporting structures, inlet and exhaust casings, or SAS connector parts are likely to be re-used from the first test campaign but major components such as the HPT stage and TVF assembly will be delivered as new hardware. Where needed, the instrumentation plan will be modified in close collaboration between GEDE and the partner. However, consistency between the test 1 and 2 objectives, requirements, and instrumentation is envisaged wherever to enable a back-to-back system and component aerodynamic performance comparison between the two test vehicles.

WP 6 – Test 2 Rig Assembly and Commissioning

In this work package, the test 2 hardware delivered by GEDE will be assembled at the partner's facility, connected to the supporting instrumentation/data acquisition systems, and to the SAS. As in WP 2, calibration of all instrumentation before (and after) the tests is needed to ensure the reliability of the test results. Due to the installation of new hardware, rotor balancing and rig alignment will have to be re-done. After the rig assembly is completed, commissioning of the rig will have to be carried out.

WP 7 – Test 2 Execution

This work package covers the rig operation to complete second test campaign in the project and the generation of all related test data. Test requirements, operating conditions, safety and alert limits, and test schedule will be jointly reviewed by GEDE and the partner during the test preparation phase. Consistent with test 1, variations of TVF inlet conditions (e.g. by varying the HPT exit flow angle, HPT clearance setting, or HPT purge flow levels) and in the TVF exit conditions (LPT rotor at design and off-design operation) are planned again.

WP 8 – Test 1 and 2 Data Comparison

Work package 8 contains the post-processing tasks related to all test data acquired during the second measurement campaign. In addition, a detailed comparison of the test 1 and 2 post-processed data is needed, with particular emphasis on identifying TVF aerodynamic loss mechanisms and quantifying differences in these mechanisms depending on the characteristics of the TVF inlet and exit conditions. This analysis is aimed at determining additional design improvement opportunities relative to the test 2 TVF configuration.

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
WP 2	Rig 1 assembly and commissioning report	R	T0 + 5 months
WP 3	Test campaign 1 completed	D	T0 + 10 months
WP 3	Delivery of tests 1 raw data and observations	R	T0 + 10 months
WP 4	Report summarizing test 1 post-processed results	R	T0 + 14 months
WP 6	Rig 2 assembly and commissioning report	R	T0 + 21 months
WP 7	Test campaign 2 completed	D	T0 + 24 months
WP 7	Delivery of tests 2 raw data and observations	R	T0 + 24 months
WP 8	Report summarizing test 2 post-processed results and comparison to test 1 results	R	T0 + 36 months

*Types: R=Report, D-Data, HW=Hardware

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
WP 1	Agreement on test 1 requirements and instrumentation	Agreement	T0 + 1 months
WP 1	Agreement on test 1 conditions and test matrix	Agreement	T0 + 1 months
WP 1	Critical Test Design Review	Review	T0 + 2 months
WP 2	Test 1 rig hardware received	Milestone	T0 + 3 months
WP 2	Test 1 rig assembled and commissioned	Milestone	T0 + 5 months

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
WP 3	Test campaign 1 completed	Milestones	T0 + 10 months
WP 5	Critical Test Design Review	Review	T0 + 18 months
WP 6	Test 2 rig hardware received	Milestone	T0 + 19 months
WP 6	Test 2 Rig assembled	Milestone	T0 + 20 months
WP 6	Test 2 Rig commissioned	Milestone	T0 + 21 months
WP 7	Test campaign 2 completed	Milestone	T0 + 24 months

*Types: R=Report, D-Data, HW=Hardware

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

It is expected that a specific set of skills, capabilities, and facilities are required to fulfill the tasks as outlined above. Thus, a response shall address the following areas:

- Demonstrated capability to operate a continuous, transonic aerodynamic turbine rig in dual-spool mode for testing of a turbine vane frame with both HPT and LPT blade rows. Capability to operate the test rig at stable and repeatable operating conditions.
- Test facility size enabling a test vehicle close to engine scale and rig operation allowing engine-representative flow conditions with TVF inlet Mach numbers around 0.4, TVF inlet Reynolds numbers (based on TVF fairing axial chord) of around 10e6, total rig pressure ratio of at least 4 (to simulate HPT and LPT stages with engine-relevant aerodynamic loadings and pressure ratios), and rotational speed capabilities to match engine-relevant corrected speed. A list of rig operation requirements is given below:

Parameter	**Unit**	**Value**
Total rig pressure ratio	-	> 4
Rig mass flow	kg/s	> 10
HPT shaft power	MW	> 1
LPT shaft power	MW	> 0.25
HPT corrected speed Nd/sqrt(TT_{in})*	rpm-m/sqrt(K)	> 200
LPT corrected speed Nd/sqrt(TT_{in})*	rpm-m/sqrt(K)	> 100
TVF inlet Mach number	-	0.3 – 0.5
TVF inlet Reynolds number	-	~10e6

* Here, N is the rotational speed in rpm, d is the rotor tip diameter in m, and TT_{in} denotes the total temperature at the inlet of the rotor

- Experience with providing multiple purge mass flows to HPT and LPT rotors through a secondary air system with independent control over mass flow levels and temperatures.
- Demonstrated capability to acquire detailed two-dimensional flow field measurements using standard rake and five-hole probe instrumentation and data reduction processes enabling HPT/TVF/LPT system and component performance evaluation.
- Capability to operate at stable mass flow conditions and to measure the main mass flow with an uncertainty of less than 1.5 %.
- Feasibility to use existing torquemeters or install new torquemeters on the two spools to quantify the efficiency of the HPT and LPT stages.
- Possibility to use existing tip clearance measurement system or implement new system for monitoring HPT rotor tip gap and knowledge of gap size during aerodynamic data acquisition downstream of the HPT.
- Capability to include advanced instrumentation and experience with unsteady data acquistion, such as fast response aerodynamic pressure (FRAP) or hotwire probes for studying unsteady flow and component interaction mechanisms as well as determining turbulence levels at multiple stations along the flowpath.
- Experience with the assembly of complex test vehicles, implementation of conventional and advanced instrumentation, and assessment of measurement uncertainties.
- Experience in R&T and R&D collaborative projects, with demonstrated portfolio of successfully executed turbine test programmes and proven avility to resolve unforeseen challenges during commissioning and testing phases.
- Proven track record with the setup of data acquisition systems and the execution of industry-standard data reduction methods
- Experience in delivering technical and programme planning documentation, risk analyses, post-processed test results and test reports to an industry partner.

5. Abbreviations

ACARE	Advisory Council for Research and Innovation in Europe
FRAP	Fast response aerodynamic pressure
GEDE	GE Germany
HPT	High-pressure turbine
LPT	Low-pressure turbine
SAS	Secondary air system
TCF	Turbine centre frame
TRL	Technology readiness level

TVF	Turbine vane frame
UHPE	Ultra-high propulsive efficiency
WP	Work package

IV. Development of innovative methods and tooling for machining of slender shafts

Type of action (RIA or IA)	RIA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP 2		
Indicative Funding Topic Value (in k€)	400		
Topic Leader	GKN	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[59]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CFP06-ENG-01-18	**Development of innovative methods and tooling for machining of slender shafts**
Short description	
New jet engine designs incorporate a more slender LPT shaft and this challenges the manufacturing processes. This topic asks for technology development in the areas of new intelligent and sensorized tool concept for internal machining of bottle bore geometry where the L/D is above 30.	

[59] The start date corresponds to actual start date with all legal documents in place.

1. Background

The Clean Sky 2 programme aims at developing and demonstrating competitive and environmentally friendly technology for commercial air transport. One technology strand consists of demonstration of a new engine architecture called UHPE (Ultra High Propulsive Efficiency Engine) for a short/medium range aircraft. The new architecture will be demonstrated through an engine ground test and a wide range of new components need to be developed and manufactured.

A key architecture change compared to previous engines is the introduction of a power gearbox decoupling the Fan rotation from the turbine rotation. This means that the engine drive shaft will transfer the fan power at around three times higher RPM than previously which means that torque will decrease. The relative engine core size will also be reduced due to a core engine with higher specific power. These effects will enable and enforce a diameter reduction of the drive shaft compared to current engines. As a consequence the internal contour bore dimensions and manufacturing tolerances will be challenged. This topic asks for technology development in the areas of new intelligent tool concept for internal machining of bottle bore geometry where the L /D is above 30 and lengths are above 2 meters.

Since the shaft is a safety critical component, it is of importance to monitor the machining process and chip formation and evacuation to early detect trends in properties that may lead to defects or producibility problems. Internal machining of very slender objects is today not supported but an industrialized machining concept.

This Topic description proposes the following work breakdown structure to address the problems described above:

- WP1 – Establishment of requirements and concepts for new tool system
- WP2 – Sensors, signal processing and presentation
- WP3 – Tool and system design
- WP4 – Demonstation and verification
- WP5 – Project management

WP1 shall establish all requirements for the new tool and tool suporting system (machine, pumps and other items). These requirements shall be fed to all other WPs. Available technology shall be analyzed. Concepts for possible solutions are to be investigated and concepts and a system design are to be chosen.
WP2 shall investigate, and decide on sensors and signal processing techniques, preferably SOTA and COTS. The work package should also investigate methods for surface condition prediction based on sensor outputs, as well as methods of presenting information and using statistical information for controlling the process.
WP3 shall design the tool and any supporting systems for tool including tool motion, machine interfaces. Chip control and evacuation from the relatively small cavities in modern LP shafts are imperative. Emphasis on chip forming process, chip breaking and evacuation, as well as monitoring of chip forming and evacuation process is important. Possible means to solve this task may include coolant flow simulation, chip forming simulation, insert geometry development and application of dedicated sensors in the tool and machine hardware.
WP4 shall develop machine interfaces for the new tool, including tool slide motion. Improvements to

tool slide positional control in relation to existing designs shall be made. WP4 shall demonstrate the new concept by machining a bottle bore in a relevant part. The demonstration can be performed as a limited test sequence on high alloyed high strength steel (Maraging 250, or second priority Allvac HCM3) at the Topic Managers production site in a typical multitask machine (WFL M65, Sinumerik 840D).

The development is forseen to be performed within the consortium while the final demonstration should be conducted at the Topic manager's site.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
WP1	**Establishment of requirements and concepts for new tool system** The task should capture all requirements for a new tooling concept for the new tool. Possible configurations and concepts shall be developed and analysed. WP will be the basis of work performed in particular in WP2 and WP3.	M10
WP2	**Sensors, signal processing and presentation** Based on the required monitoring strategy, the sensor types shall be identified and their integration to the tool investigated. The sensors should be placed in such a way that the measurement is accurate. The signal processing for the sensors, including sensor fusion should be developed as well as the means for presenting the process to the human, and for storage and statistical work.	M18
WP3	**Tool and system design** The package is responsible for designing the tool and tool concept, as well as building and making the concept ready for test.	M20
WP4	**Demonstration and verification** The tooling concept is to be demonstrated in a multioperation machine. The demonstration shall include chip monitoring, tool insert condition monitoring and prediction of surface integrity prediciton.|	M24

WP5	**Project Management** The partner shall nominate a team dedicated to the project and should inform CfP Topic manager about the name/names of this key staff. At minimum the responsibility of the following functions shall be clearly addressed: Programme (single point contact with Topic Manager), Engineering & Quality. ***Progress Reporting & Reviews*** Monthly one-pager and quarterly progress reports in writing shall be provided by the partner, referring to all agreed work packages, technical achievement, time schedule, potential risks and proposal for risk mitigation. Regular coordination meetings shall be installed (preferred as telecom). The partner shall support reporting and agreed review meetings with reasonable visibility on its activities and an adequate level of information. The review meetings shall be held quarterly by WEBEX, at Topic Manager's premises or at the partner's premises.	

3. Major Deliverables/ Milestones and schedule (estimate)

Please fill in the table to identify the deliverables expected from the CfP, and provide an estimated schedule (graphic elements preferred).

Deliverables			
Ref. No.	***Title – Description***	***Type****	***Due Date***
D1.1	System requirements	R	M3
D1.2	Concepts for intelligent tool design	R	M10
D2.1	Chosen sensors, signal processing	R	M18
D3.1	Tool design	R	M15
D4.1	Demonstration hardware	HW	M20
D4.2	Demonstration report	R	M23
D5.1	Detailed project plan	R	M2

*Types: R=Report, D-, HW=Hardware

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1.1	Requirements review	R	M3
M2.1	Concept review tool design and sensors	R	M10
M3.1	Test readiness review	R	M20
M4.1	Demonstration conducted at Topic Managers premises	Test	M22

Types: R=Report, D-Data, HW=Hardware

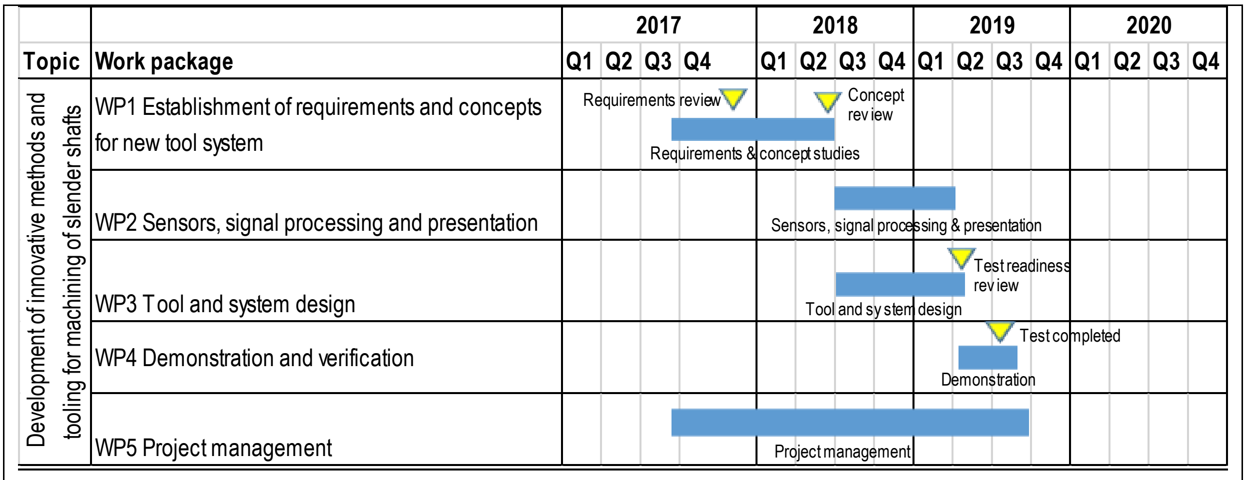


Figure 1. Estimated project time schedule

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

- Skill 1: Deep hole machining and bottle bores – and tooling design for these processes

  The consortium must have extensive competence within general machining, internal turning, turning with extreme overhangs and turning using internally supported tooling. In addition, due to the very slender geometry of LP shafts, knowledge on supported tooling is beneficial.
- Skill 2: Process monitoring

  The consortium must have knowledge on machining process monitoring and the application of the measurements. The developed tooling concept that is to be developed should survey the forces, cutting edge condition and also generated surface condition and warn as early as possible of process changes, instabilites and issues with machined surface condition.
- Skill 3: monitoring of chip forming and evacuation.

  The chip process is of importance to internal machining. The shaft materials and realizable cutting conditions used may lead to changes in the chip behaviour during machining. The consortium should have competence within the chip forming process and be able to develop e method for monitoring the condition of this.
- Skill 4: Test facilities

  The consortium must have access to a test facilites for development for the demonstrator. This means some machine equipement and testing of sensors. Software for data acquistion, signal processing is imperative.

5. Abbreviations

COTS	COmmercially available of The Shelf
LP	Low Pressure
LPT	Low Pressure Turbine
SOTA	State Of The Art
UHPE	Ultra High Propulsion Efficiency (engine)

V. Thermoplastic Thrust reverser cascade

Type of action (RIA or IA)	IA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP 2		
Indicative Funding Topic Value (in k€)	450		
Topic Leader	Safran	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	40	**Indicative Start Date**[60]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CFP06-ENG-01-19	**Thermoplastic Thrust reverser cascade**
Short description	
Safran Nacelles need some opportunity to mature a potential alternative technology to provide a better ratio between aerodynamic performance and cost for Thrust Reverser Cascades made with composite materials than the current technology, in particular for direct flow reversing cascades.	

[60] The start date corresponds to actual start date with all legal documents in place.

1. Background

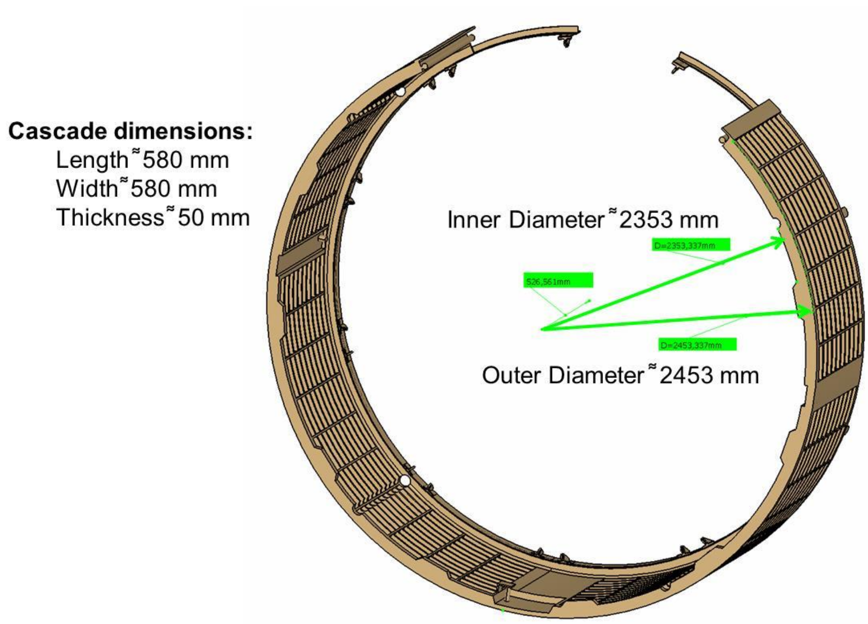
Through Clean Sky 2, Safran aim to develop and demonstrate nacelle technology bricks to enable an Ultra High By-pass Ratio (UHBR) engines. Baseline configuration for the demonstrator is made of new low pressure modules and nacelle parts integrated around an existing or adapted HP core in order to form the required ground demonstrator with a by-pass ratio anticipated within the range 15-20.

The work intended to be covered by the selected Partner will concern the development and the maturation of a technology based on the injection moulding of high performance thermoplastic resins reinforced with carbon fibres. Injection moulding is a very fast and economical process, which can lead to substantial cost reduction. Furthermore the exact quantity of material is injected so no waste is generated during the manufacturing. Thermoplastics are also more easily recycled than thermosets. As a demonstration of the capability of the technology, the Partner will work on the development of structural cascades for typical UHBR core engines for short/medium aircrafts. Furthermore throughout this collaboration with the Partner, Safran seek to identify other applications of the thermoplastic injection technology. The demonstration of the capability of the technology on cascade is considered because of the complexity of the design of these parts.

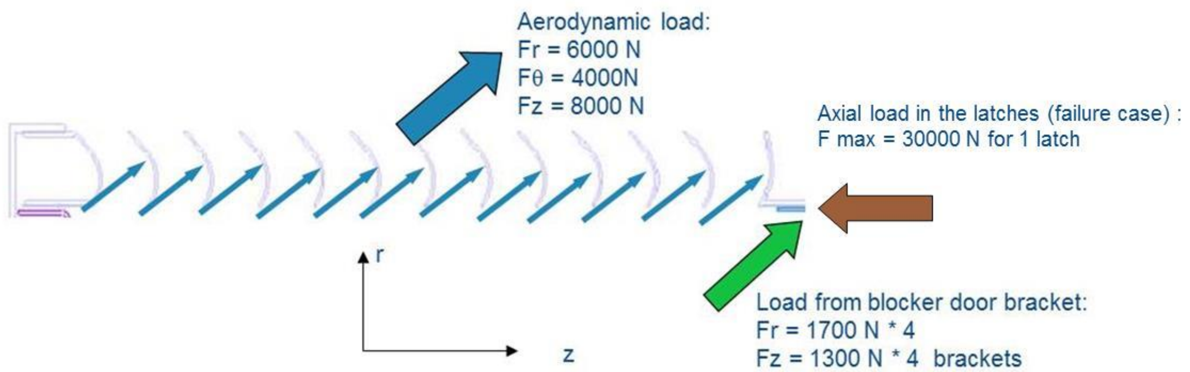
The actual version of composite cascades uses continuous fibres in a preferential direction, which makes them to be more resistant to bending in that direction but significantly less resistant to tensile loads. The work of the Partner will therefore aim to develop and manufacture self-supporting cascades. The Partner shall demonstrate the capability to manufacture cascades showing different design complexities using injection moulded carbon fibre reinforced composite materials. The resulting material shall demonstrate the capability to withstand the required load cases at a competitive cost and mass. The Partner shall also demonstrate a relevant experience and a strong knowledge on the subject and on the specificities of the proposed technology in relationship with the type of part concerned by this proposal. Therefore a TRL 4 is expected to be already achieved by the Partner prior to this development program, especially in highly loaded part with complex shape.

2. Scope of work

Typically 24 cascades are integrated in an engine thrust reverser system, as shown in the figure below, in order to allow the deviation of the air flow in required directions.



The cascades are typically submitted to the loads described in the figure below:



The cascades also have to withstand intense vibrations applied by the engine and displacements forced by the surrounding structure. The maximum in-service temperature is about 100 °C.

Furthermore the current classical hand layup process implies a minimal distance between the cascade blades, which induces a minimal cascade hight in order to respect the performance requirements in the reverse mode. That is not compatible with the UHBR nacelle design concerned by this call. The Partner will therefore demonstrate the capability to manufacture cascades with composite materials that enable to solve the criterion of minimal distance between the blades. The chosen material will show homogeneous properties charactersitics in all directions to make them be self-supporting.
Each cascade shall also respond to the following needs:

- Weight ≤ 1 kg
- Cost < 500 € (at a production rate of 500 parts per year)

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 0	Project planning - Schedule in accordance with the description of work showing the completion of the project as per the deadline	T0 + 1 month
Task 1	Definition of technological demonstrators addressing the singularities of the design of the different types of cascade and of the process and associated testing plan - On a trust reverser, there are different types of cascades depending on its location around the engine as the air flow direction is to be adapted to the close environment (ground, wing, 2nd engine …). The target would be to define the minimum number of prototype allowing to validate all the singularities shown on a whole set of cascade. - Definition of the test plan to be performed (on coupons or on prototypes) to prove the compliance with the structural requirements.	T0 + 3 months
Task 2	Manufacture and testing of the technological demonstrators - Manufacturing of the prototype(s) as defined in Task 1 - Mechanical tests to be performed as defined in Task 1	T0 + 11 months
Task 3	Definition of a set of cascades to be tested on the ground demonstrator - Design of the cascades to be tested on the ground test demonstrator. As explained in task 1, there would be different design (3 to 5) depending depending on the location of the cascade around the engine	T0 + 15 months
Task 4	Manufacture of a set of cascades for the demonstrator - Manufacturing of the cascades defined in Task 3	T0 + 20 months
Task 5	Analyse of the test results - Final report including results from the tests of the Task 2 and from the Ground Test campaign	T0 + 36 months

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type (*)***	***Due Date***
D1	Preliminary Design Review summary and action close-out report	R	T0 + 3 months
D2	TRL 5 review summary	R	T0 + 12 months

D3	Critical Design Review summary and action close-out report	R	T0 + 15 months
D4	First parts delivery for the demonstrator	D	T0 + 20 months
D5	TRL 6 review summary	R	T0 + 36 months

*Type:
R: Report

RM: Review Meeting

D: Delivery of hardware/software

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
MS 1	Preliminary design review	RM	T0 + 3 months
MS 2	TRL 5 review	RM	T0 + 12 months
MS 3	Critical design review	RM	T0 + 15 months
MS 4	TRL 6 validation	RM	T0 + 36 months

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

- Strong knowledge and background on the composite materials and injection moulding process applied to complex geometry and aeronautic requirements.
- Achieved TRL 4
- Mechanical testing
- Manufacture and monitoring of structural parts made in composite materials
- Engineering and Manufacturing Engineering staff
- Process simulation and mechanical analysis

VI. Long Fiber Thrust reverser cascade

Type of action (RIA or IA)	IA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP 2		
Indicative Funding Topic Value (in k€)	450		
Topic Leader	Safran	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	40	**Indicative Start Date**[61]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CFP06-ENG-01-20	**Long Fiber Thrust reverser cascade**
Short description	
Safran Nacelles need some opportunity to mature a potential alternative technology to provide a better ratio between aerodynamic performance and cost for Thrust Reverser Cascades made with composite materials than the current technology.	

[61] The start date corresponds to actual start date with all legal documents in place.

1. Background

Through Clean Sky 2, Safran aim to develop and demonstrate nacelle technology bricks to enable an Ultra High By-pass Ratio (UHBR) engines. Baseline configuration for the demonstrator is made of new low pressure modules and nacelle parts integrated around an existing or adapted HP core in order to form the required ground demonstrator with a by-pass ratio anticipated within the range 15-20.

The work intended to be covered by the selected Core Partner will concern the development and the maturation of a technology using long discontinuous fibre (DLF) reinforced thermoset composite materials.

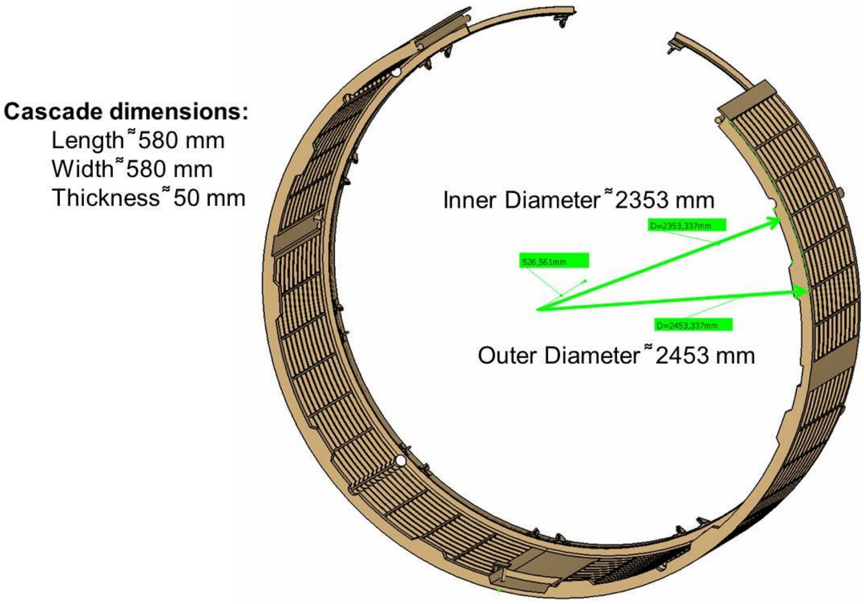
Long discontinuous fibre thermosets enable short process cycle in comparison with classical hand lay-up technology as they are similar to sheet moulding compounds while providing high technical performance. They also enable complex 3-D shapes and reduce, if not eliminate, the production of waste during manufacturing.

As a demonstration of the capability of the technology, the Partner will work on the development of structural cascades for typical UHBR core engines for short/medium aircrafts. Furthermore throughout this collaboration with the Partner, Safran seek to identify other applications of the DLF thermoset moulding technology. The demonstration of the capability of the technology on cascade is considered because of the complexity of the design of these parts.

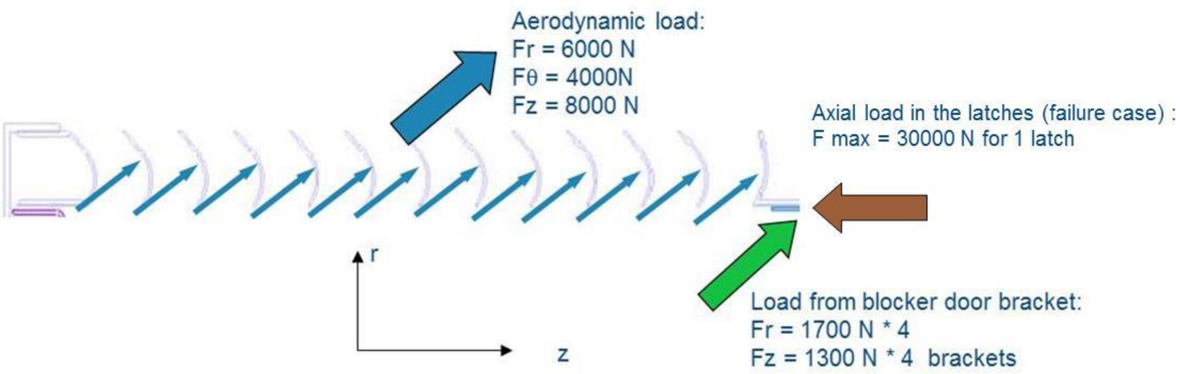
The actual version of composite cascades uses continuous fibres in a preferential direction, which makes them to be more resistant to bending in that direction but significantly less resistant to tensile loads. The work of the Partner will therefore aim to develop and manufacture self-supporting cascades. The Partner shall demonstrate the capability to manufacture cascades showing different design complexities using DLF reinforced composite materials. The resulting material shall demonstrate the capability to withstand the required load cases at a competitive cost and mass. The Partner shall also demonstrate a relevant experience and a strong knowledge on the subject and on the specificities of the proposed technology in relationship with the type of part concerned by this proposal. Therefore a TRL 4 is expected to be already achieved by the Partner prior to this development program, especially in highly loaded parts with complex shape.

2. Scope of work

Typically 24 cascades are integrated in an engine thrust reverser system, as shown in the figure below, in order to allow the deviation of the air flow in required directions.



The cascades are typically submitted to the loads described in the figure below:



The cascades also have to withstand intense vibrations applied by the engine and displacements forced by the surrounding structure. The maximum in-service temperature is about 100 °C.

Furthermore the current classical hand layup process implies a minimal distance between the cascade blades, which induces a minimal cascade height in order to respect the performance requirements in the reverse mode. That is not compatible with the UHBR nacelle design concerned by this call. The Partner will therefore demonstrate the capability to manufacture cascades with composite materials that enable to solve the criterion of minimal distance between the blades. The chosen material will show homogeneous properties charactersitics in all directions to make them be self-supporting.

Each cascade shall also respond to the following needs:

- Weight ≤ 1 kg
- Cost < 500 € (at a production rate of 500 parts per year)

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 0	Project planning - Schedule in accordance with the description of work showing the completion of the project as per the deadline	T0 + 1 month
Task 1	Definition of technological demonstrators addressing the singularities of the design of the different types of cascade and of the process and associated testing plan - On a trust reverser, there are different types of cascades depending on its location around the engine as the air flow direction is to be adapted to the close environement (ground, wing, 2^{nd} engine …). The target would be to define the minimum number of prototype allowing to validate all the singularities shown on a whole set of cascade. - Definition of the test plan to be performed (on coupons or on prototypes) to prove the compliance with the structural requirements.	T0 + 3 months
Task 2	Manufacture and testing of the technological demonstrators - Manufacturing of the prototype(s) as defined in Task 1 - Mechanical tests to be performed as defined in Task 1	T0 + 11 months
Task 3	Definition of a set of cascades to be tested on the ground demonstrator - Design of the cascades to be tested on the ground test demonstrator. As explained in task 1, there would be different design (3 to 5) depending depending on the location of the cascade around the engine	T0 + 15 months
Task 4	Manufacture of a set of cascades for the demonstrator - Manufacturing of the cascades defined in Task 3	T0 + 20 months
Task 5	Analyse of the test results - Final report including results from the tests of the Task 2 and from the Ground Test campaign	T0 + 36 months

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type (*)***	***Due Date***
D1	Preliminary Design Review summary and action close-out report	R	T0 + 3 months
D2	TRL 5 review summary	R	T0 + 12 months
D3	Critical Design Review summary and action close-out report	R	T0 + 15 months
D4	First parts delivery for the demonstrator	D	T0 + 20 months
D5	TRL 6 review summary	R	T0 + 36 months

*Type:

R: Report

RM: Review Meeting

D: Delivery of hardware/software

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
MS 1	Preliminary design review	RM	T0 + 3 months
MS 2	TRL 5 review	RM	T0 + 12 months
MS 3	Critical design review	RM	T0 + 15 months
MS 4	TRL 6 validation	RM	T0 + 36 months

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

- Strong knowledge and background on the composite materials and injection moulding process applied to complex geometry and aeronautic requirements.
- Achieved TRL 4
- Mechanical testing
- Manufacture and monitoring of structural parts made in composite materials
- Engineering and Manufacturing Engineering staff
- Process simulation and mechanical analysis

VII. Aerothermal characterization in the engine compartment

Type of action (RIA or IA)	RIA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP 3		
Indicative Funding Topic Value (in k€)	900		
Topic Leader	Safran	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[62]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CFP06-ENG-01-21	**Aerothermal characterization in the engine compartment**
Short description	
Numerical analysis of air flow behaviour in the engine bay with transient aerothermal coupling method. Unsteady numerical simulations will be performed for shutdown conditions to analyse the air flow in the engine bay and in the engine's internal channel. Network level methods and the impact on the equipments skin temperatures will be investigated.	

[62] 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 in 2019 with capability to be part of the next generation of aircrafts.

The turboprop engine demonstrator will be based on an existing core engine. New modules will be developped specifically for the turboprop installation such as an advanced power & accessory gear box, a new air inlet and a new propeller. Gas Turbine core components will be studied for improved performances, in particular regarding turboprop applications.

A full Integrated Power Plant System (IPPS) will be ground tested. To assess the engine installation into the nacelle, a comprehensive study is necessary, in particular regarding the thermal management in the engine bay.

An example of the engine bay (or engine compartment), which consists of the air flow under the engine hood (transparent domain), is shown in figure 1. The figure 2 shows the work breakdown structure of the whole demonstration platform.

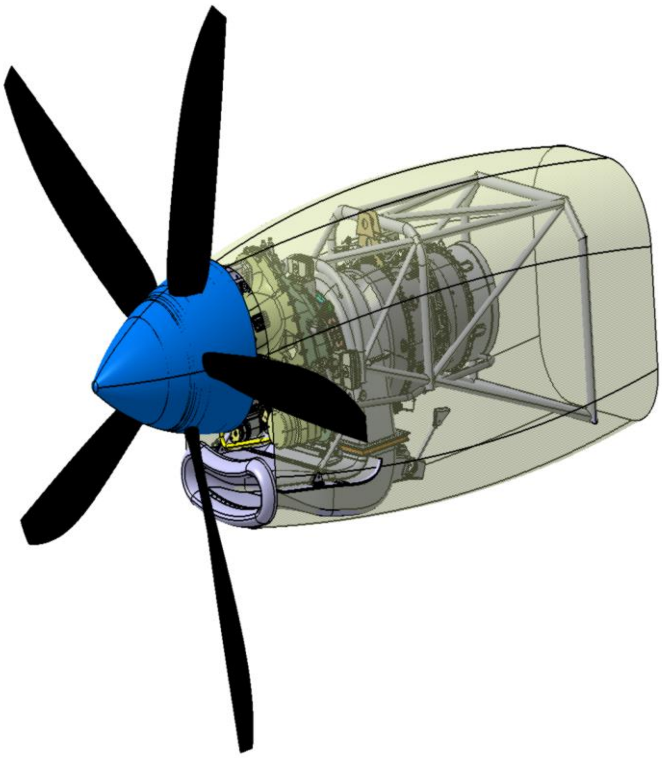


Figure 11: Illustration of WP3 Integrated Power Plant System (IPPS)

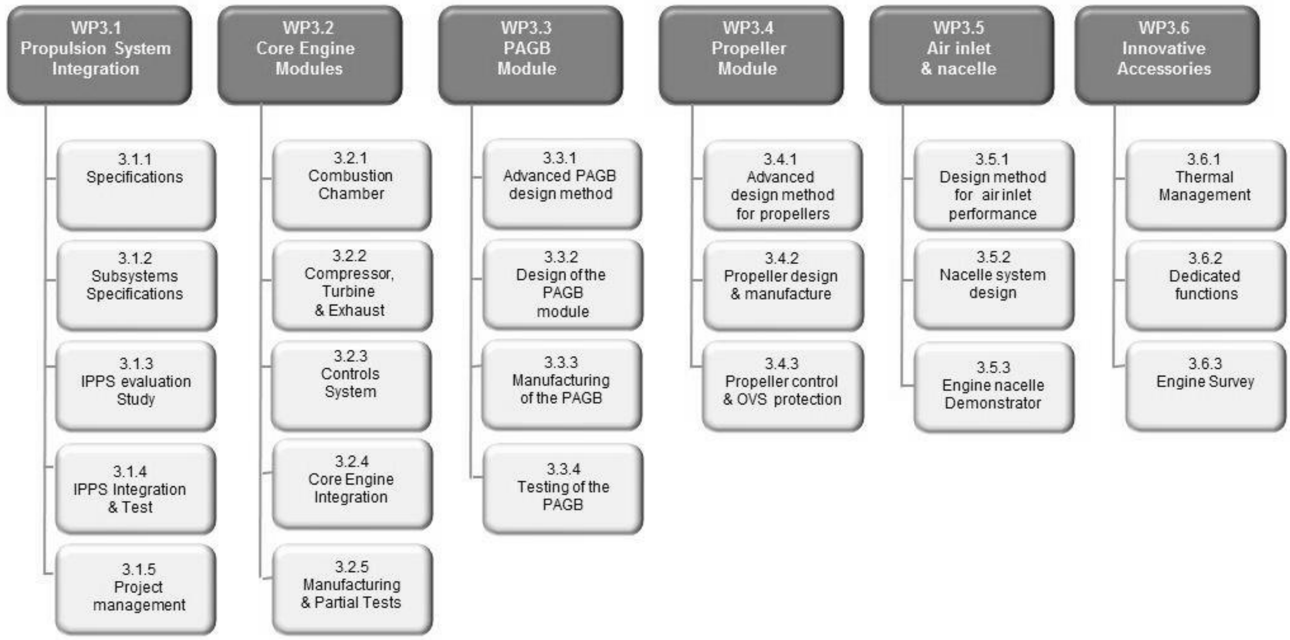


Figure 12: WP3 Work breakdown structure

2. Scope of work

The main purpose of this project is to simulate the engine aerothermal behaviour after shutdown, using Lattice Boltzmann Methods (LBM).

Heat soaking (or soak back) is a major concern to optimize the engine's integration, especially for the thermal design of the various equipments (electronics/electrical components, harness, etc.) that are attached to the engine casing in the engine compartment.

Therefore, modeling this transient phase requires a transient aerothermal coupling method of both convection, conduction and radiative heat transfers. An additionnal difficulty is to be able to resolve a large range of flows in the same transient simulation that is: high Mach number flows at the very beginning of the engine shut down and then free convection. Finally, the accuracy of this kind of calculation is highly conditionned by a good capture of heat transfers from the engine internal channel (main flow path, rotor and stator, secondary air system and cavities under the engine casing) to the air flow under the engine hood. This can be achieved either by including the resolution of the complete engine, in particular the internal main flow path, in addition to the engine compartment (high calculation cost) or by modeling only the engine bay with very accurate thermal boundary conditions at the inner face of the casing.

As a result, the main target of this project is to generate a 1D network model of the engine's internal channel (main flow path, solids parts, simplified secondary air system and simplified cavities under casing) for heat soaking purpose.

The activity will particularly consists in running simulations using Lattice Boltzmann Methods (LBM) and all the simulations will focus on the engine shut down phase as mentionned above.
First, an engine compartment LBM simulation will be conducted to understand flow phenomenology under the hood on the existing engine core used to design the turboprop demonstrator.
In a second step, solely the engine's internal parts will be considered with a growing modeling complexity in order to elaborate a representative 1D network model. Then both the engine internal parts (main flow, solids, cavities, etc.) and the engine bay air flow will be simulated. The final aim will be to couple the 1D network model to a transient LBM simulation of the engine compartment and then to calibrate this model relative to available experimental data.
The strategy for the simulations is illustrated on the scheme in figure 3.

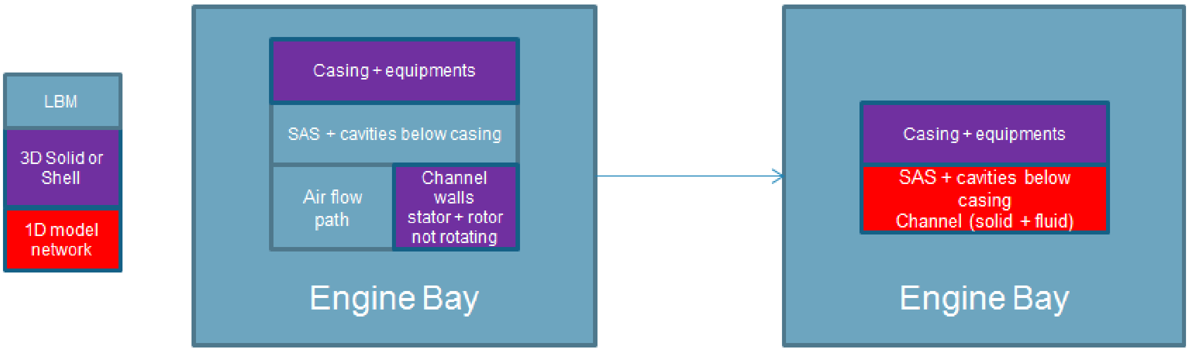


Figure 13: Strategy for the simulations

Five activity streams are identified. It is expected that the partner has already readily available numerical tools to perform the tasks.

<u>Task 1 : LBM simulation of the engine compartment</u>
The task 1 will be dedicated to establishing general guidelines for the numerical analysis of engine compartment with LBM and the results will be compared to available experimental data on a turboshaft engine. A "blind test" will be conducted on the existing engine core used to design the turboprop demonstrator. This test will consists in a LBM aerothermal simulation of the engine bay coupled to a first approximated 1D network model of the engine's internal channel. All the solids (casing, equipments, engine's internal solid parts) will be treated as shell elements.

Because heat soaking can last during quite a long period after engine shut down (up to a few hours), the duration of the transients must be agreed prior to simulations; the rationale will be a trade-off between the calculation cost and the physical time simulated that is needed to correctly capture thermal behavior. Simulations will be conducted to verify the impact of the transient profile during the first minute of the engine shutdown phase. As a consequence, capability to run LBM simulations at high Mach number is mandatory.

Task 2 : The details of the engine casing will be taken into account

This task will consist in introducing more complexity in the model, in particular regarding the engine casing. The partner will update the LBM simulation to include the 3D engine casing walls and then by modeling the cavities below the engine casing.

Task 3 : Aerothermal LBM simulation of the engine's internal channel will be computed to build a 1D network model

First, the internal channel (entire air flow path + rotor and stator solids) will be generated in CAD file by the partner based on the existing 2D (revolution) modules and 3D modules of the engine. SafranHE will provide initial fields and boundary conditions.

Secondly, a simplified transient aerothermal modeling of the engine's internal parts will be performed during the entire shut down phase. A 1D network model of the whole engine's internal air flow path (main flow path and secondary air system) will be implemented whereas solid parts (rotor and stator) will be modeled as shell elements.

The complexity will gradually be raised by :

- reprensenting all the solid parts in 3D instead of shell elements,
- then by modeling the main flow path with LBM
- and finally by modeling even the secondary air system with LBM (including all heat tranfers).

The final most complex modeling, that is LBM for the whole air flow path and 3D for rotor and stator solids, will be used to enrich the first simplified model.

Task 4: The engine's internal channel will be included in the model of the engine compartment - Tools calibration

The partner will complete the models generated within task 3 with the model of the full engine bay set up in task 2. The simplifed 1D model of the engine will be coupled to the engine bay LBM simulation as well as the whole LBM model of the engine's internal channel.

Complete simulations will be to compared to available experimental data. Safran Helicopter Engines will provide the necessary experimental data, that are available on an existing turboshaft engine installation. On one hand, full LBM simulations with aerothermal coupling will be assessed regarding heat soaking issue. On the other hand, the partner will calibrate the 1D model to match with the experimental data. Therefore, a validated methodology combining 1D network model of the engine's internal channel and LBM simulation of the engine compartment will be proposed to simulate heat soaking. The partner will also provide a detailed feedback and best practices on this methodology to ensure a strong capitalisation of this work for future designs.

Task 5 : Application on the Turboprop demonstrator

Finally, the methodology built in task 4 will be applied on the turboprop integrated power plant system to analyze the air flow behavior during engine shutdown.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 0	*Project Management* **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 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 at the topic manager's facility.	T0 + 36 months
Task 1	***LBM simulation of the engine compartment*** • To establish general guidelines for the numerical analysis of the engine compartment using LBM, • The results will be compared to available experimental data	T0 + 6 months
Task 2	***Model with detailed engine casing*** • To developp a more complex model, in particular regarding the engine casing and the cavities below the engine casing • To run LBM simulations including the 3D engine casing walls and cavities below engine casing	T0 + 12 months

Task 3	***Aerothermal LBM simulation of the engine's internal channel and building of a corresponding 1D network model*** • To generate a CAD file of the internal channel (entire air flow path + rotor and stator solids) based on the existing 2D (revolution) modules and 3D modules of the engine • To developp a simplified transient aerothermal model of the engine's internal parts • To enrich the first simplified model using LBM for the whole air flow path and 3D for rotor and stator solids	T0 + 18 months
Task 4	***Model with detailed engine casing, engine's internal channel and engine compartment*** • To complete the models generated within task 3 with the model of the full engine bay built in task 2 • To compared the simulations with available experimental data • To report detailed feedback and best practices on the methodology applied to combine 1D network model of the engine's internal channel and LBM simulation of the engine compartment	T0 + 24 months
Task 5	***Simulations of tuboprop engine in the engine bay*** • To apply the validated methodology on the Turboprop demonstrator	T0 + 30 months

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type (*)***	***Due Date***
D1	Report with guidelines approach & methodology	R	T0 + 4 month
D2	Report on simulation (engine bay)	R	T0 + 6 months
D3	Progress Report	R	T0 + 12 months
D4	Report on simulations (isolated engine)	R	T0 + 18 months
D5	Report on simulations (engine + engine bay) and tools calibration	R	T0 + 24 months
D6	Report on TP simulations (engine + engine bay)	R	T0 + 30 months
D7	Final report (including updated methodology)	R	T0 + 36 months

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type (*)***	***Due Date***
MS 1	1st Progress Review	RM	T0 + 12 months
MS 2	2nd Progress Review	RM	T0 + 24 months
MS 3	Final Review	RM	T0 + 36 months

* Type:

R: Report

RM: Review Meeting

D: Delivery of hardware/software

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

Technologies such as Aerodynamic, Aeromechanical, Mechanical, Material, Manufacturing and Methods will be required for supporting the experimental investigations.

Strong expertise in numerical simulations and analysis is required.

The partner will demonstrate to have recognized skills in:

- Aerodynamic & Mechanics
- High Performance Computing for Computational Fluid Dynamics (CFD) simulations
- Lattice Boltzmann Method (LBM)
- 1D network approaches for aerothermal purpose
- Transient aerothermal simulation coupling conduction, convection and radiation
- High Mach number simulations
- Free convection simulations
- Heat soaking
- Computer Assisted Design (CAD) using CATIA software
- Available numerical tools to perform the tasks

VIII. Advanced Instrumented Engine cradle of the Turboprop demonstrator

Type of action (RIA or IA)	IA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP 3		
Indicative Funding Topic Value (in k€)	400		
Topic Leader	Safran	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[63]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CFP06-ENG-01-22	**Advanced Instrumented Engine cradle of the Turboprop demonstrator**
Short description	
To Design and manufacture the engine cradle that will support the engine on ground in the test facility. The purpose is to develop a light weight engine cradle with advanced instrumentation (in particular, loads, vibrations, temperatures). The applicant will also propose numerical studies over the flight envelope, focusing in particular on vibration damping and to be later compared with the tests results. The study shall take into account the installation of various equipments in the engine bay (air cooling oil cooler, actuators, etc).	

[63] 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 in 2019 with capability to be part of the next generation of aircrafts.

The turboprop engine demonstrator will be based on an existing core engine. New modules will be developped specifically for the turboprop installation such as an advanced power & accessory gear box, a new air inlet and a new propeller. Gas Turbine core components will be studied for improved performance.

A full Integrated Power Plant System (IPPS) will be ground tested. The main components of the IPPS are:

- The engine,
- The cradle where the engine is attached,
- The aircraft air intake together with the nacelle and
- The propeller.

The IPPS is illustrated in figure 1. The engine cradle is the tubular structure that is used to sustain the engine into the nacelle. The engine cradle that will be used during ground tests shall be representative of a real installation, in particular regarding design constraints.

The figure 2 shows the work breakdown structure of the whole demonstration platform.

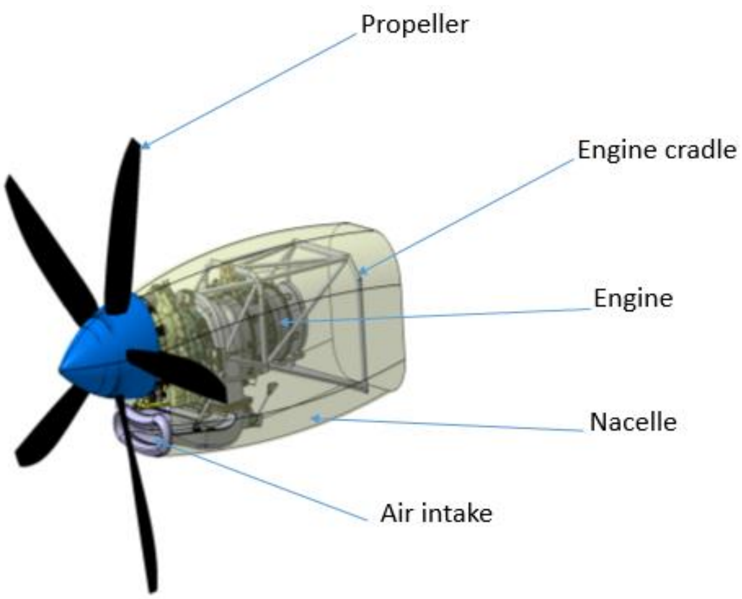


Figure 14: Illustration of WP3 Integrated Power Plant System (IPPS)

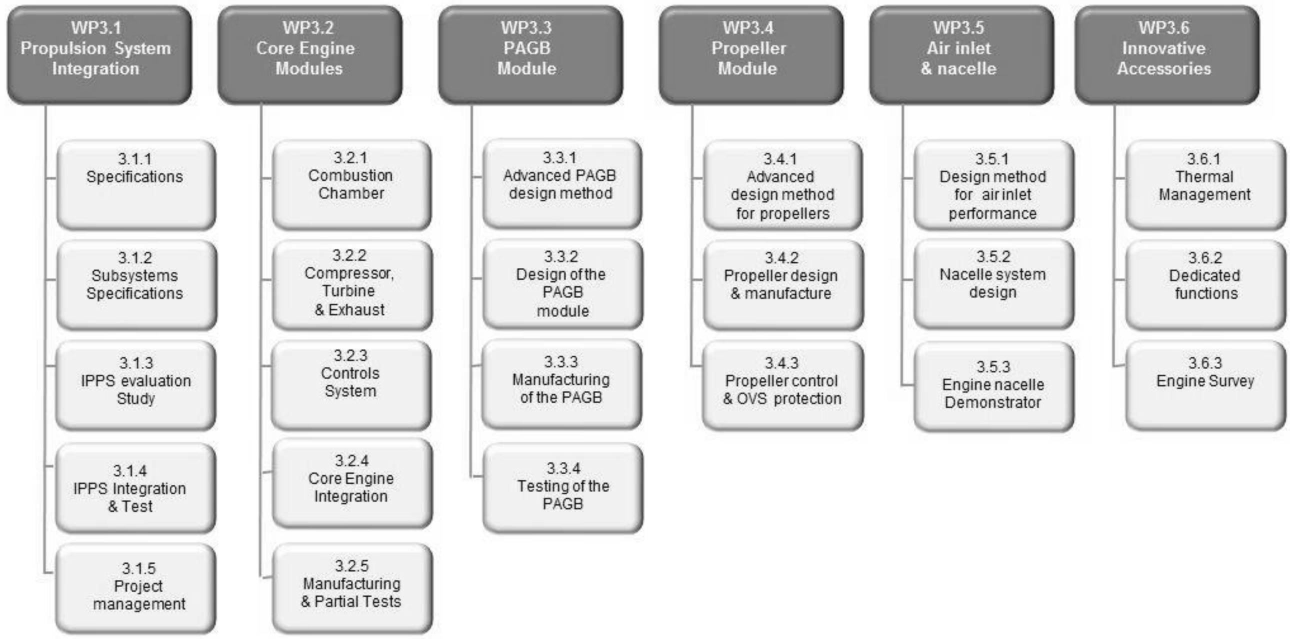


Figure 15: WP3 Work breakdown structure

2. Scope of work

The purpose is to improve and optimize the engine installation configurations for weight savings and performance optimization. The main activities will focus on the following topics:

- Analysis of current state of the art regarding engine installations
- Design of the engine cradle for the turboprop engine ground tests
- Manufacturing and instrumentation of the engine cradle
- Characterization of the engine compartment ventilation system

To assess the engine installation into the nacelle, a comprehensive study is necessary, including the ventilation of the engine bay. Following the installations studies, the partner will design and deliver a scale 1:1 optimized engine cradle for the turboprop engine ground tests at SafranHE Engine Test Facility.

Therefore five main tasks are identified, which are described in the following.

Task 1: Benchmark on current engine installations

A benchmark will be performed to analyze current turboprop engines installations and compartments.

Among outputs of the benchmark study, information and analysis on the following items will be provided:

- mechanical interfaces
- electrical interfaces

- systems interfaces for controls
- safety analysis (including list of feared events and potential systems failures with associated consequences, including the list of associated failure probabilities to address regulation requirements)

The associated report will provide recommendations/suggestions for installation improvement.

Task 2: Design of the engine cradle

The partner will study and design an optimized engine cradle for the engine ground demonstration purpose. The design will be conducted such as to be compliant with CS23 regulation rules. SafranHE will provide the theoretical flight enveloppe; in particular, up to six cases will be considered regarding the mechanical loads.

The engine is attached to the cradle with three points: two at the front, one at the back, using specific engine mounts. The architecture of the engine mounts is already frozen. SafranHE will provide the interfaces for the engine mounts to the cradle. Discussions will be conducted with SafranHE and the engine mount supplier to define the specific properties (in particular regarding vibration damping, etc..).

Task 3: Substantion for Engine cradle design

The full computations and analysis will be provided to SafranHE. It will not include substantation for a flight test.

Task 4: Manufacturing of advanced instrumented Engine cradle

The partner will study the instrumentation of the engine cradle based on SafranHE specifications. He will propose advanced solutions for instrumentation and deliver the full engine cradle with instrumentation.

Positions for instrumentation are shown on the figure 3. Preliminary requirements for cradle instrumentation are listed herafter:

Three-axes Accelerometers:

- 1 to 3 : engine surveillance (provided by SafranHE)
- 4 to 6 : surveillance of the engine cradle
    - 2 at the front, 1 at the back (near engine mounts)
- 7 : surveillance at the back of the cradle

Strain gauges:

- 1 to 5 : near engine mounts
- 6 to 7 : on the cradle, at the front and at the back

Thermocouples:

- 1&2: on the engine mounts

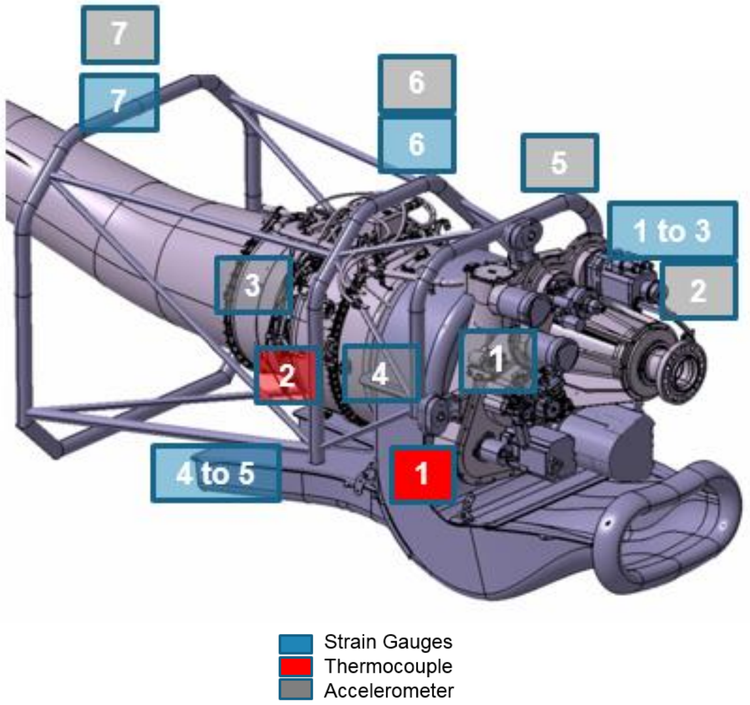


Figure 16: Preliminary requirements for cradle instrumentation

Prior to delivery, the partner will perform relevant tests to ensure that the cradle is compliant to the needs and that the instrumentation is operational. In particular, a static load test of the engine cradle is necessary to verify the resistance of the welds of the tubular structure.
The engine mounts hardware are not part of the delivery of this activity.

Task 5: CFD analysis for engine ventilation assessment

CFD analysis will be performed to assess the engine air flow environment during flight, taking into account ventilation air inlets on the nacelle. The CFD analysis will include the thermal behaviour of the nacelle equipments, engine cradle and engine mounts and engine casings. The engine bay will remain unchanged (design frozen). Nevertheless two to three geometries for ventilation intake will be considered.

About 10 flight cases (manoeuvers loads, gust loads, various air flows on the nacelle inlet port for ventilation) will be considered for the CFD simulations of the air flow within the engine compartment. The model will include air inlets ports on the nacelle walls for ventilation purpose.

SafranHE will provide data such as:

- Temperature, pressure and air flows at air intakes
- Static pressure at exhaust
- Casing temperatures

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 0	*Project Management* **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 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 at the topic manager's facility.	T0 + 24 months
Task 1	***Benchmark on current engine installations*** To analyse current state-of-the-art configurations	T0 + 3 months
Task 2	***Design of Engine cradle*** To propose an optimization of the engine installation in the nacelle and to design the associated engine cradle	T0 + 3 months
Task 3	***Substantion for Engine cradle design*** To report and substantiate the design process with all results of computations and material showing the cradle will withstand all efforts during engine ground tests	T0 + 4 months
Task 4	***Manufacturing of advanced instrumented Engine cradle*** To manufacture and instrument the engine cradle and do a static load test prior to delivering the cradle to SafranHE	T0 + 8 months
Task 5	***CFD analysis for engine ventilation assessment*** To perform CFD air flow simulations within the engine bay	T0 + 12 months

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	Technical report on benchmark with study on engine interfaces	R	T0 + 3 month
D2	3D CAD model for the engine cradle	D	T0 + 3 month
D3	Technical report with explanation on chosen or discarded solutions	R	T0 + 4 month
D4	2D Manufacturing drawings (with and without instrumentation)	D	T0 + 6 month
D5	ANSYS Model of the engine cradle to be included in Whole Engine Model	D	T0 + 4 month
D6	Instrumented engine cradle delivery	HW	T0 + 8 month
D7	Technical report on functional test of engine cradle	R	T0 + 8 month
D8	Technical reports with substantiations on engine cradle	R	T0 + 10 month
D9	User manual for engine cradle	R	T0 + 8 month
D10	Final Report	R	T0 + 24 month

*Types: R=Report, D-, HW=Hardware

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
MS 1	1st Progress Review (benchmark, design, …)	RM	T0 + 4 month
MS 2	2nd Progress Review (manufacturing)	RM	T0 + 8 month
MS 2	Final Review (feedback, lessons learned, …)	RM	T0 + 20 month

*Types: R=Report, D-Data, HW=Hardware

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

Technologies such as Aerodynamic, Aeromechanical, Mechanical, Material, Manufacturing and Methods are required.

The partner will demonstrate to have recognized skills in the use of multidisciplinary tools:

- Catia CAD
- ANSYS
- CFD tools (Fluent)

5. Abbreviations

CFD	Computational Fluid Dynamics
IPPS	Integrated Power Plan System
ACOC	Air cooling Oil Cooler

IX. IP Turbine Rear Stages Aero/Noise Rigs

Type of action (RIA or IA)	IA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP 5.2 Technologies for IPTs		
Indicative Funding Topic Value (in k€)	2250		
Topic Leader	ITP	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[64]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CFP06-ENG-03-15	**IP Turbine Rear Stages Aero/Noise Rigs**
Short description	
The work will comprise the aerodynamic rig testing associated to the WP5.2 needed to allow ITP to develop aerodynamic and acoustic validated technology for the rear stages of VHBR IP Turbine. Aerodynamic design will be provided by ITP to the partner. The work to be performed by the partner in the CfP comprises detail design, including drawings, hardware manufacturing, rig assembly and instrumentation, rig testing and supply of all test data.	

[64] The start date corresponds to actual start date with all legal documents in place.

1. Background

WP5.2 is devoted to develop technologies for IP Turbines of VHBR engines, in order to apply these technologies to the design of the IP Turbine for the engine demonstrator in WP6.1.1. It is important that all the technologies reach the right validation before their introduction in the engine demonstrator in order to reduce the associated risk to the adequate level. However, due to the timescales of the program, not all the technologies that will be introduced in the engine demonstrator will be fully validated in advance.

As part of the technology development, task 5.2.3.4 is focused on aerodynamic and aeroacoustic technology of IP Turbines for VHBR engines. It is recognised that these turbines have significant differences with respect to those used in the civil turbofans currently in service, for what a significant aerodynamic and aeroacoustic technology development is required. For aerodynamics the main areas of study will be:

- The front part of the turbine featuring a very low aspect ratio vane.
- The mid-rear part of the turbine featuring high aspect ratio aerofoils with high transonic Mach number.
- The tip region to minimise the over tip leakage which has a severe impact in this turbine configuration. Special attention will be paid if the need of partial shrouds is confirmed, as the detrimental effect in efficiency will be larger.
- Interaction of cavity – main stream flows, which is a major source of losses, especially in high Mach number flows.
- The exit structure to understand the potential risks and opportunities coming from a significantly higher inlet Mach number.

For acoustics it is clearly envisaged that advanced noise reduction technologies will be required. In particular, 3D optimised vanes and clocking as well as other technologies focused in the first stage nozzle guide vane. Both aerodynamics and acoustics technologies will be jointly developed as they heavily influence each other and for this reason, should also be validated in the same vehicle and test.

The development of the above technologies will require a first phase of conceptual studies followed by the application of the technologies to the design of several test vehicles that will be then manufactured and tested. Data analysis, comparison with design intent and validation of the tools will be the final step.

For a succesfull development of the technologies, the test vehicles should cover different TRL levels. The lowest ones will allow to have detailed measurements and understanding of the physics of the problem, while the highest ones will validate the technologies in a relevant environment.

From an aero-acoustics point of view there is a good split between technologies related to the front part of the IP turbine and technologies related to the rear part. Validation of the technologies associated to the front part will be done by means of VT3-1 and VT3-2 rigs. Technologies related to the rear stages of the IP turbine will be validated up to TRL5 with VT4-1, VT4-2 and VT4-3 1 ½ stages rigs. However, a multistage rig of the rear stages including the rear structure is required to characterize how these technologies interacts and therefore to validate them in a further TRL.

2. Scope of work

The work will comprise the aerodynamic rig testing associated to the WP5.2 needed to allow ITP to develop validated technologies for the VHBR IP Turbine. Aerodynamic design will be provided by ITP to the partner. The work to be performed by the partner in the CfP comprises detailed design (including drawings), hardware manufacturing, rig assembly and instrumentation and rig testing. The partner will supply all experimental data to ITP to complete technology validation process. The work includes one (1) aerodynamic multistage rig (test vehicle) named VT2. It will consist of the last two stages of the VHBR IP Turbine and the rear structure.

Figure 1 shows a schematic of the VT2 configuration. It consists of a first row of IGVs followed by the last two stages and rear structure of VHBR IP Turbine.

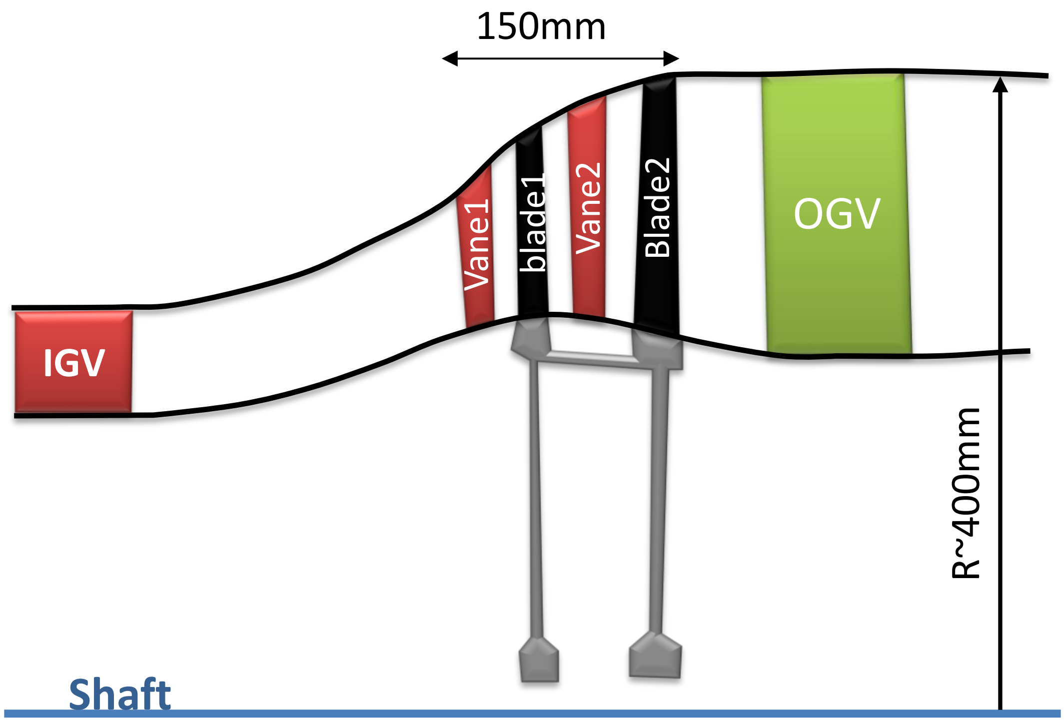


Figure 1. Schematic of VT2 configuration

VT2 rig will include all the technologies developed in WP5.2 that have been already included in VT4-1, VT4-2 and VT4-3 1 ½ stages rigs. VT2 is intended to provide a further validation in order to understand how these technologies interact when included together in the same vehicle. In particular, it is important to verify if the overall benefit of the technologies is the sum of the individual benefits of each of them.

Within the scope of the work is the detailed design of all the parts, including those required to adapt the rig to the facility, hardware manufacturing, rig assembly and instrumentation and rig testing. Aerodynamic design of the wetted surfaces of all the parts will be provided by ITP. Four tasks have been defined related to the activities listed above.

In addition, a reference multistage rig test should also be included in the scope of work. The necessity of this reference test will be explained later.

<u>Task 1:</u> Rig mechanical design

Aerodynamic definition of all the wetted surfaces will be provided by ITP. Within Task 1 scope is the mechanical design of all the parts as well as the analysis required to ensure the structural integrity of the rig during the operation. Also included in this task is the definition of the manufacturing models and drawings required by the suppliers. Manufacturing quality should be according to ITP standard (e.g. Airfoil profile tolerance 0,10 mm, wetted surfaces roughness 0,8 µm,…).

One of the technologies to be proved is airfoil clocking. With this purpose, the mounting system should allow the possibility to change clocking position between stator 1 and stator 2, covering at least eight different clocking positions. This should be done without opening the rig to reduce as much as possible measurements uncertainties between subsequent tests.

VT2 rig should have capability to simulate and modify purge flows.

<u>Task 2:</u> Instrumentation design

The rig should be designed to include the following instrumentation:

- At least 25 degrees area traverse measuring between IGV and vane 1 and between rotor2 and OGV. Two circumferential locations will be required in all the traversing planes. At all these traversing planes, measurements with minituarised five-hole probes and Hot Wire probes should be taken.
- At the measurement plane between IGV and vane area traverse with temperature probes should also be done.
- Total pressure and total temperature rakes between IGV and vane 1 and downstream of OGV
- Inlet boundary layer should be traversed at inlet plane with miniaturised boundary layer probes or any non-intrusive measurement system.
- Static pressure tappings in suction and pressure sides of vane 1, vane 2 and OGV at five span locations (2%, 30%, 50%, 70% and 98%). Also, hotfilm gauges should be placed at midspan section of vane 1, vane 2 and OGV. Instrumentation has to be non-intrusive, tubes must be routed through the aerofoil and surface reconstructed to design intent wetted surface.
- Tip clearance probes should be placed in the outer casing to measure rotors tip clearance in all test conditions.
- A Noise Measurement Module (NMM) that allows for a 360^{o} traverse should be placed downstream of the rig. This module should be instrumented with at least two arrays of Kulite sensors for noise measurement. If required, it should also include a liner to avoid reflections in any structure downstream of the NMM that could affect noise measurements of VT2.
- Area traversing at OGV exit will be done by means of a probe fixed to the NMM. In addition, total pressure and total temperature rakes will also be mounted on the NMM.
- Inlet mass flow and purge flows should be measured, as well as shaft speed and torque.

All the instrumentation to be used should be statically and dynamically calibrated in an environment representative of the test conditions. The calibration range should cover:

- Reynolds number from cruise to Sea Level conditions
- Mach number up to 0.9
- Yaw and pitch angles from -60 to +60 degrees

Task 3: Assembly and balancing

VT2 Rig should be assembled according to the following requirements:

- Airfoil verification in different sections to be inspected and provided in electronic format.
- Record radial clearance between IGVs and flow path at tip and hub sections.
- Measurement of interplatform gaps of each row to ensure an equispaced distribution of airfoils.
- Concentricity adjustment of internal and external casing with shaft, to reduce eccentricity.
- Cold build clearance of all rotors to be recorded during assembly.
- Axial setting to correct the axial position between rotative and static parts.
- All possible undesired leakage paths should be sealed and documented at rig assembly.
- Rotor trim balance to reduce vibration levels and avoid rotordynamic problems.
- Trim balance process to be performed with a pre-assembly of the rotor installed in the facility, in order to avoid rubbing during the process. An additional trim balance should be performed once the final rig module assembly is completed.
- Leakage test of the rig with all the instrumentation installed should be performed. All the pressure lines to be individually tested over the completed range of operating conditions to assure 'zero' leakage. Lekakage test of the rig to be repeated for each instrumentation configuration, before and after of testing.
- Setting the position and angle of all the traversing probes installed in the rig is required

Task 4: Rig testing

Test matrix of VT2 should include the following test conditions:

- Sensitivity to Reynolds number.
- Turbine map characterization, covering a range of conditions representative of VHBR IP Turbine. This will include conditions to evaluate the IP Turbine behaviour in a Shaft Break Event.
- Sensitivity to purge flows.
- Noise measurements should be taken in operating conditions representative of noise points of VHBR IP Turbine.
- Sensitivity to clocking position. Performance and noise measurements should be taken at all the different clocking positions.

Area traverse measurements in all the traversing planes should be done in all the test conditions.

A global rig efficiency uncertainty less than ± 0.2% with a repeatability less than ± 0.1% is required.

Task 5: Testing of the reference rig

The objective of VT2 rig is to characterize, in a multistage environment, aerodynamic performance and noise levels of rear stages of VHBR IP Turbine in order to assess the benefit of the VHBR engine related to state of the art Turbofans. As a consequence, is mandatory to compare the results of VT2 rig with a reference multistage rig representative of the rear stages of a state of the art LPT. This reference rig should be tested in the same facility with the same instrumentation. This is because it is already known that rig performace is highly affected by inlet conditions, turbulence levels, flow quality, among other characteristics that are different for each test facility. Therefore, comparing with a reference rig tested in the same facility with the same instrumentation is the only way to reduce uncertainties to the level required, and allow to have a back to back comparison between aerodynamic technology of VHBR IP turbine to be developed in WP 5.2 and former LP Turbine technology. This is key to assure that the benefit of the technologies is achieved. If this rig is not available, ITP can provide an existing one. Then, the scope of work should also include the hardware required to adapt the rig to the facility and the testing.

Task 6: Project Management

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:

- A number of progress reports and deliverables will have to be submitted over the duration of the programme. These are supported by the submission of an Engineering Communication Memo (ECM) with the evidence of the work attached.
- For all work packages, technical achievements, timescales, potential risks and proposal for risk mitigation will have to be monitored, reported and actively managed.
- 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 face-to-face review meetings to discuss the progress of the programme, exact schedule to be agreed at the beginning of the project.
- Status reports will be provided to ITP and Rolls-Royce to demonstrate progress of the project on a timescale to be agreed at the beginning of the project. All analysis, assessments, test results and conclusions will be documented and provided to ITP and Rolls-Royce in an agreed format.

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T1	Rig mechanical design	M0-M9
T2	Instrumentation design	M0-M9
T3	Assembly and balancing	M6-M12
T4	Rig testing	M10-M24
T5	Testing of the reference rig	M0-M24
T6	Project Management	M0-M24

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D1.1	VT2 rig part drawings	Drawings	M9
D1.2	VT2 structural analysis report	Report	M9
D2.1	VT2 instrumentation drawings	Drawings	M9
D3.1	VT2 rig assembly report	Report	M12
D3.2	VT2 rig balancing report	Report	M12
D4.1	VT2 test schedule	Report	M12
D4.2	VT2 calibration report	Report	M12
D4.3	VT2 test report	Report	M24
D5.1	Annual Project Review - to include a status report of the project that details the status of the deliverables, milestones, level of spend and dissemination.	Report	M12
D5.2	Project Closure Review - to include a status report of the project that details the status of the deliverables, milestones, level of spend and dissemination.	Report	M24
Milestones (when appropriate)			
M1.1	VT2 rig design review		M9
M2.1	VT2 rig instrumentation design review		M9
M3.1	All VT2 parts available at facility		M10
M3.2	VT2 Test Readiness Review		M12
M4.1	Pass to test of VT2		M12
M4.2	End of test of VT2		M20
M4.3	VT2 Post Test Review		M22

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

The Applicant needs to demonstrate to be in the position to have access to the test facilities required to meet the Topic goals:

- Continuous transonic wind tunnel for aerodynamic turbine rig testing, with at least the following capabilities:
    - Rotational speed: 15000 RPM
    - Mass flow: 16 Kg/s.
    - Inlet total pressure: 100 kPa.
    - Exit total pressure: 12 kPa
    - Inlet temperature: 450 K.
- High-speed wind tunnel for dynamic calibration of instrumentation at representative test conditions. Calibration capability at different Reynolds number and Mach numbers is mandatory. Reynolds number range from sea level to high altitude should be covered. Mach numbers up to 0.9 should be tested.

Test facilities have to be already commissioned and general description has to be presented by the Applicant when replying to this Call.

Proven experience and capability of measuring efficiency of a multistage rig with an uncertainty less than ± 0.2% and with a repeatability less than ± 0.1%.

Proven experience and capability of the test facility to adjust operating conditions with a high level of stability and repeatability are required.

Proven experience in performance and noise testing with different clocking positions between rows.

Proven experience in measuring at transonic flow conditions

Relevant previous experience in managing and delivering successfully aerodynamic rig test programmes needs to be demonstrated.

Extensive developed capability of rig hardware modifications with flexibility and modularity concepts is required.

Proven experience in the mechanical design of rig components for different applications and adaptation hardware to test facility, are mandatory. Significant experience in rig concept definition and managing interfaces between rig and test facility are critical.

Significant experience in detail design is required. Modeling and detailed drawings to be performed in Unigraphics NX 7.5 or higher.

Experience in Supply Chain management is mandatory. Access to an established and competitive supply chain for manufacturing of rig hardware, needs to be demonstrated.

Extensive and proven experience in instrumentation design, calibration, and integration of instrumentation into rig modules is mandatory.

As described before the instrumentation capabilities should cover at least the following requirements:

- Provision for up to 700 pressure channels and 160 temperature channels.
- Accurate mass flow measurements in main flow and in secondary purge flows.
- Area traverse measurements.

- Fast response multi-hole probes and temperature probes.
- Total temperature and pressure rakes.
- Boundary layer probes.
- Rotor tip clearance measurements during rig running.
- Hotwire and hotfilm anemometry.
- A minimum of 40 kulite pressure sensors for noise measurements to be acquired simultaneously.

Significant experience in rig assembly process, including trim balance capability, is mandatory.

Availability of testing and measurement technologies at a high readiness level (TRL≥6) to minimize program risks is an asset in order to minimize the risk.

Demonstrated portfolio of successful programme rigs and proven ability to understand and resolve events during commissioning and testing period, are essential.

Experience in aerospace R&T and R&D collaborative programs is a benefit. The activity will be managed with a Phase & Gate approach and management plan has to be provided. The Topic Manager will approve gates and authorize progress to subsequent phases.

Technical/program documentation, including planning, drawings, risk analysis, FMEA, test plan and test requirements, test results, test reports must be made available to the Topic Manager.

5. Abbreviations

IGV	Inlet guide vane
IP	Intermediate pressure
NMM	Noise measurement module
OGV	Outlet guide vane
TRL	Technology readiness level
VHBR	Very high by-pass ratio

X. Development of non-intrusive engine emissions instrumentation capability

Type of action (RIA or IA)	IA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP 5 – VHBR – Middle of Market Technology		
Indicative Funding Topic Value (in k€)	2000		
Topic Leader	Rolls-Royce	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[65]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CFP06-ENG-03-16	**Development of non-intrusive engine emissions instrumentation capability**
Short description	
To develop and demonstrate non-intrusive measurement and 2D tomography of nvPM/soot and CO2 concentrations in aero-engine exhaust. Validation of the technology will require measurement of representative lean burn combustion emissions conditions and supporting data analysis including relevant measurement uncertainty confirmation. System level validation will require the supply of a robust hardware and analysis system for whole engine demonstrators. The measurement system should be developed to a maturity level of TRL6 with a route to commercialisation.	

[65] The start date corresponds to actual start date with all legal documents in place.

1. Background

Through Clean Sky 2, Rolls-Royce are developing and demonstrating the complete range of technologies required for Very High Bypass Ratio engines.

Within the timescales of Clean Sky 2, Very high bypass ratio engines will realize significant environmental benefits:-

- Up to 25% fuel burn and CO2 emission reduction relative to year 2000 baseline (consistent with 10% reduction relative to year 2014 baseline)
- Noise levels making a significant step towards to ACARE 2035 targets (- 11 EPNdB per operation relative to 2000 situation: including engine, nacelle, aircraft technologies - airframe noise reduction, novel aircraft configurations – and ATM benefits)
- Contribute to delivery of non-volatile particulate matter (nvPM)/soot and NOx emission reductions through reduced fuel burn. Specific objectives will not be defined owing to the strong dependency on overall core engine cycle decisions.

One of the key technologies developed to meet the goals of WP5/6 is an efficient, optimised engine core. Future VHBR engines represent significant challenges for accurate engine performance prediction and aerothermal prediction and control.

The higher the engine BPR, the more challenging it becomes to precisely predict engine performance. In addition, transient core cooling variation adds further uncertainty into understanding and development of an efficient engine core built in a VHBR architecture. There is a need to develop core mass flow measurement capability to improve and optimise engine performance prediction and control for both steady state and transient conditions. Measurement of core mass flow can be achieved using direct measurement of engine exhaust emitted CO2 concentration and engine fuel flow. To obtain representative engine exhaust CO2 emissions requires a spatial tomography measurement system to fully map the entire engine core exhaust.

Complexity of VHBR lean burn combustion systems requires careful fuel control and optimised staging especially for nvPM emissions. Intricacies of injector to injector fuel flow variation will impact the temperature distribution through the turbine. Development of 2D mapping of combustor injector variation will improve lean burn combustion system robustness to extreme operating conditions and meet certification requirements. This can be achieved via 2D measurement of engine exhaust nvPM concentrations emitted.

In order to ensure that the benefits of future VHBR products are fully realised, then these future engine core systems are required to be optimised and controlled to ensure that the increase in BPR does not penalise fuel burn or nvPM emissions, and are more efficient to ensure optimum cycle performance across the engine operating range. Development of non-intrusive engine exhaust emissions measurement capability will provide a tool for engine core optimisation.

The work intended to be covered by the Partner selected will be to develop and demonstrate non-intrusive (no impact on engine performance - no hardware installed in engine exhaust/plume/entrained air) engine exhaust measurement technologies required to deliver robust engine performance prediction and lean burn combustion operation on future VHVR engines. This should be interpreted as delivering a TRL6 standardised measurement system capable of imaging large engine exhaust CO2 and nvPM emissions of future VHBR engines.

The developed measurement technologies should be demonstrated through engine testing. There is no specific testing requirement on an RR engine test, the partner can propose testing on their own engine hardware, as long as demonstration of the scope technology capability is met.

The successful Partner will demonstrate both the capability to deliver cutting edge optical technology based on established track records of innovation, capability and availability, as well as a proven and established capability for the delivery of optical product ranges. This implies demonstration of strong evidence of existing research and development facilities, design and maintenance support capabilities and demonstrated readiness of the corresponding measurement system supply chain.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
WP 1	Management	T0 + 6 months
WP 2	CO2 imaging measurement system development	T0 + 12 months
WP 3	nvPM (soot) imaging measurement system development	T0 + 12 months
WP 4	Measurement system validation	T0 + 24 months
WP 5	Standardisation of measurement system	T0 + 24 months

The main objective of this project is to develop and demonstrate a non-intrusive measurement system capable of 2D imaging of engine exhaust CO2 and nvPM/soot emissions in future large civil VHBR and lean burn combustion aeroengine applications.

Additionally the measurement technologies developed through this programme should be seen as the building blocks for further work relating to engine performance and lean burn combustion enhancements over a further period of time with the target of improving reliability, efficiency and emission targets future VHBR lean burn combustion turbofan aeroengine applications.

The measurement technology described herein must be capable of imaging engine combustion exhausts of at least 1 m in diameter and to ensure measurement hardware has no impact on engine performance (by being placed outside entrained engine air flow), non-intrusive optics shall be placed a minimum 3.4 m from engine centre-line. The imaging spatial resolution shall be <10 cm. The measurement system requires transient 1 Hz capability.

The measurement uncertainty of CO2 concentration shall be better than 4% and preferably 2%.

The measurement uncertainty of nvPM/soot concentration shall be better than 30% and preferably 15%.

To enable the delivery of a successful programme five distinct work packages (WP) have been identified. WP 1 for the management, WP 2 for development of CO2 imaging measurement system, WP 3 for development of nvPM (soot) imaging system, WP 4 for measurement system validation and WP 5 for Standardisation of the measurement system. It is expected that the five work packages will run concurrently enabling appropriate tests to follow a specific development.

The measurement system should be developed to a maturity level of TRL6 and therefore should utilise existing commercialised products where possible.

WP 1 – 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:

- Four 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

WP 2 – CO2 imaging measurement system development

This work package focuses on the development of the non-intrusive CO2 concentration measurement system to measure representative lean burn combustion CO2 emissions. Optimisation of the system architecture, DAQ, measurement determination and image reconstruction are essential to produce a commercialized system in work package 5. The majority of this work package will take place in the first 12 months.

The tasks for this work package are:

- Develop multi-beam optical hardware for CO2 measurement and imaging of engine exhaust including system health monitoring and control:
    - System shall be capable of measuring concentration range 1.5 to 5 % CO2
    - System shall be capable of achieving 1 Hz CO2 measurement and imaging
    - Calibration measurement protocols shall be developed
- Develop software for measurement algorithms
- Develop software for control and data acquisition
- Develop tomographic image reconstruction software
- Develop and define protocols for image interpretation

WP 3 – nvPM/soot imaging measurement system development

This work package focuses on the development of the non-intrusive nvPM/soot concentration measurement system to measure representative lean burn combustion nvPM/soot emissions. Optimisation of the system architecture, DAQ and measurement determination are essential to produce a commercialized system in work package 5. The majority of this work package will take place in the first 12 months.

<u>The tasks for this work package are:</u>

- Develop optical hardware for nvPM/soot measurement and imaging of engine exhaust including system health monitoring and control
    - System shall be capable of measuring nvPM/soot concentration range 40 ug/m3 to 5 mg/m3
    - System shall be capable of achieving 1 Hz nvPM/soot measurement and nvPM/soot imaging at steady state engine conditions
    - Calibration measurement protocols shall be developed
- Develop software for measurement algorithms
- Develop software for control and data acquisition

WP 4 – Measurement system validation

This work package focuses on the demonstration of the CO2 and nvPM/soot measurement systems on engine testing. There is no specific testing requirement on an RR engine test, the partner can propose testing on their own engine hardware.

This testing will efficiently provide validation of the measurement system including measurement uncertainty and end user operation (linked to work package 5) and enable improvements in system control. The majority of this work package is expected to take place after 12 months.

The tasks for this work package are:

- Evaluate CO2 and nvPM/soot measurement systems on multiple engine tests
- Compare measurements with extractive techniques
- Evaluate measurement uncertainty performance

WP 5 – Standardisation of Measurement system

This work package focuses on the demonstration of the CO2 and nvPM/soot measurement systems as a robust commercialised system (TRL 6). The standardisation process will build on work packages 2 to 4. This work package will work in parallel to all other work packages throughout the 24 months.

The tasks for this work package are:

- Develop CO2 and nvPM/soot measurement hardware system as a commercialised product including training
- Establish simplified, standardised measurement procedure and user interface for robust implementation by industry qualified technical staff
- Establish long term support for measurement system

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D1	Provide report on CO2 measurement and imaging system hardware and software	Deliverable	12 months
D2	Provide report on nvPM/soot measurement and imaging system hardware and software	Deliverable	12 months
D3	Demonstrate engine measurement validation and uncertainty	Deliverable	24 months

D4	Demonstrate measurement system at TRL 6	Deliverable	24 months

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Management report	Report	6 months
M2	Define CO2 measurement system hardware	Agreement	3 months
M3	Define nvPM/soot measurement system hardware	Agreement	3 months
M4	Define CO2 Calibration strategy	Agreement	6 months
M5	Define nvPM/soot calibration strategy	Agreement	6 months
M6	CO2 multi-beam imaging system	Product	12 months
M7	nvPM/soot measurement and imaging system	Product	12 months
M8	Define engine test plan requirements	Agreement	12 months
M9	Evaluate CO2 imaging on engine exhaust	Report	18 months
M10	Evaluate nvPM/soot imaging on engine exhaust	Report	18 months
M11	Provide system training	Product	24 months
M12	Final report / user manual for CO2 and nvPM/soot measurement system	Report	24 months

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

It is expected that a specific set of skills and facilities are required by the candidate and it is therefore expected that the response will address the following areas of expertise as a minimum:

- Established optical system development and manufacture
- Ability to provide optical system long term support
- Ability to integrate physical engine test units and instrumentation at aerospace test facilities.
- A proven record of measurement system test facility management
- Ability to correlate engine performance to engine exhaust emissions measurement at aerospace test facilities
- A proven record for non-intrusive optical CO2 measurement in combustion exhaust conditions
- A proven record for non-intrusive optical soot measurement in combustion exhaust conditions
- Ability to multiplex large datastreams over a network
- Ability to develop software for large dataset interpretation
- A proven record for tomographic methods development and interpreting tomographic

reconstruction software

XI. VHBR Engine – Journal Bearing Technology

Type of action (RIA or IA)	RIA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP 6 – VHBR – Large Turbofan Demonstrator [Ultrafan™]		
Indicative Funding Topic Value (in k€)	3000		
Topic Leader	Rolls-Royce	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	48	**Indicative Start Date**[66]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CFP06-ENG-03-17	**VHBR Engine – Journal Bearing Technology**
Short description	
To develop and demonstrate high-performance material and associated manufacturing processes for journal bearings in a lightweight aero-engine epicyclic gear box supporting planet gears under high loads and speeds. Validation of the technology will require representative sub/full-scale journal bearing rigs and supporting analysis. System level validation will require the manufacture and supply of journal bearing components to the Rolls-Royce development PGB rig and whole engine demonstrators. The material and manufacturing processes should be developed to a maturity level of TRL6 and MCRL4 respectively.	

[66] The start date corresponds to actual start date with all legal documents in place.

1. Background

Through Clean Sky 2, Rolls-Royce are developing and demonstrating the complete range of technologies required for Very High Bypass Ratio (VHBR) engines.

Within the timescales of Clean Sky 2, very high bypass ratio engines will realize significant environmental benefits:

- Up to 25% fuel burn and CO2 emission reduction relative to year 2000 baseline (consistent with 10% reduction relative to year 2014 baseline)
- Noise levels making a significant step towards to ACARE 2035 targets (- 11 EPNdB per operation relative to 2000 situation: including engine, nacelle, aircraft technologies - airframe noise reduction, novel aircraft configurations – and ATM benefits)
- Contribute to delivery of NOX emission reductions through reduced fuel burn. Specific objectives will not be defined owing to the strong dependency on overall core engine cycle decisions.

Development of VHBR technology will also maintain European competitiveness in the development and integration of engines for Middle of Market short range commercial aircraft, to ensure capability across the full range of technologies required by geared engines, and develop a world-leading European capability for Very High Bypass Ratio engines for the large aircraft market, establishing a lead in this emerging market.

Geared turbofans provide a game-changing improvement in aero-engine efficiency by allowing the fan and turbine to rotate at different speeds. This allows for a higher by-pass ratio (larger fan at a lower speed than traditional turbofans) and a lighter, faster and more efficient turbine. With the turbine and fan rotating at different speeds a gearbox is required to transfer a high level of torque within a restricted space envelope to minimise the size of the engine core. Epicyclic gearboxes provide a space efficient solution but require very high load transfer through the supporting planet bearings. Journal bearings provide a high power density (load capability for given size of bearing) and reliability compatible with geared turbofan civil aeroengine applications. The use of journal bearing in future large civil geared turbofan aeroengines presents numerous challenges as the combination of load, speed, temperature, component stiffness and extreme operating conditions is outside current industry experience. Journal bearing development is viewed as a key enabler of future geared turbofan engines. Development of journal bearing materials is required to ensure they can meet life, reliability and certification requirements and improve robustness to extreme operating conditions for future aeroengine applications.

The work intended to be covered by the Partner selected will be to develop and demonstrate various individual technologies required to deliver robust journal bearing materials suitable for use in high power gearboxes on future VHBR engines. This should be interpreted as delivering a standardised manufacturing process and production rate readiness for materials capable of meeting life and reliability certification requirements of future VHBR engines. To meet life and reliability requirements this program should include improvements to start/stop performance, robustness under low oil or mixed friction conditions, tolerance to contamination, heat generation and efficiency, thermal cyclic life. The developed technologies should be demonstrated through representative rig testing. This will include supporting R-R bearing and engine demonstration programs with development hardware.

The successful Partner will demonstrate both the capability to deliver cutting edge technology based on established track records of innovation, test facility capability and availability, as well as a proven and established capability for the delivery of this product range. This implies demonstration of strong evidence of existing research and development facilities, design and manufacturing capabilities, demonstrated readiness of the corresponding supply chain and the internal capacity to deliver in the timescales required in order to deliver world-class bearing technology for Rolls-Royce as an outcome of the joint work within Clean Sky 2. Experience with EASA flight clearance aspects or any other highly regulated industry would be advantageous.

2. Scope of work

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T1	**Material and Manufacturing Development**	
T1.1	Define materials boundary envelope	6 months
T1.2	Journal Bearing Material & Manufacturing Methods	36 months
T1.3	Material Characterisation / Data for Design	36 months
T1.4	Route to further material improvements	48 months
T2	**Validation Testing – Bearing Rigs**	
T2.1	Sub-scale journal bearing rig test - Tribology	24 months
T2.2	Full-scale journal bearing rig test – Fatigue & Endurance	36 months
T2.3	Full scale journal bearing rig tests – Extreme Conditions	36 months
T2.4	Full scale journal bearing rig tests – Assembly Proving	36 months
T3	**Manufacture and Supply – Journal Bearing Components**	
T3.1	Rolls-Royce material/functional rig	12 months
T3.2	Rolls-Royce full-scale Orbiting Rig	18 months
T3.3	Rolls-Royce PGB System Rig	24 months
T3.4	Rolls-Royce Whole Engine Demonstrator	36 months
T4	**Supporting Analysis & Assessment**	
T4.1	Lifing methods for new material – wear, fatigue, thermal	48 months
T4.2	Quantify material improvement – life, operational limits	48 months
T4.3	Rig test data interpolation & analysis	48 months
T5	**Project Management**	**48 months**

The main objective of this project is to develop and demonstrate new materials and manufacturing processes for journal bearings operating in future large civil geared turbofan aeroengine applications.

The use of journal bearings in these applications presents numerous challenges as the combination of load, speed, temperature, component stiffness and extreme operating conditions is outside current industry experience. To satisfy engine reliability requirements and ensure a robust bearing design under extreme operating conditions advancements are required in material and manufacturing processes. The operating limitations of existing materials must be determined in an aeroengine environment to guide the development of the new materials.

The technology described herein may be ultimately deployed in a number of engine markets and therefore scalability between middle-of-market and large civil applications is essential. Additionally the technologies and understandings developed through this programme should be seen as the building blocks for further work relating to material enhancements and potentially new materials over a further period of time with the target of improving reliability targets and improving journal bearing robustness for future geared turbofan aeroengine applications.

To enable the delivery of a successful programme four distinct work packages (WP) have been identified. WP 1 for the development of material and manufacturing capability, WP 2 for validation testing on representative sub-scale bearing rigs, WP 3 for manufacture and delivery of hardware to Rolls-Royce for validation on system rigs and engine demonstration, WP 4 for supporting analysis, methods development and assessment of all test results. It is expected that the four work packages will run concurrently enabling appropriate tests to follow a specific development. The material and manufacturing processes should be developed to a maturity level of TRL6 and MCRL4 respectively.

T1 – Material and Manufacturing Development

The main objective of this work package is to develop and deliver journal bearing materials and manufacturing process suitable for use in future aero-engine applications. The materials may be applied to either surface of the bearing, inner or outer, which may work individually or in combination. This has been broken down in to the following work packages.

T1.1 - Define materials boundary envelope
Initial work will confirm the boundary operational envelopes of today's journal bearing materials that may be suitable for use in high power aero-engine gearboxes. The materials will be selected out of the partner's current product range and will be agreed with Rolls-Royce.

T1.2 - Journal Bearing Material & Manufacturing Methods
A journal bearing material and manufacturing development programme focused on delivering improvements for journal bearings operating in future high power aero-engine gearboxes to meet life and reliability certification requirements. These should be assessed as improvements to start/stop performance, robustness under low oil or mixed friction conditions, tolerance to contamination, heat generation and efficiency, and thermal cyclic life; the assessment and validation of these improvements is undertaken in WP 2, 3 & 4.

T1.3 - Material Characterisation / Data for Design
A material characterisation activity which should include material, mechanical and thermal properties to

inform material specifications, through-life and OEM inspection criteria, and component analysis. Understanding of material integrity and degradation behavior under a range of representative operational conditions such as start/stop, fatigue, loss of lubrication and debris ingestion should be undertaken in conjunction with the relevant tests performed in WP 2. Material data is required to support future designs compatible with Rolls-Royce data quality standards.

T1.4 - Route to further material improvements
This work package will focus on the development of a technology strategy for further improvements in journal bearing materials for operation in a geared turbofan aeroengine above the improvements delivered under WP 1.2. This, if successful may form the basis of a future development programme.

T2 – Validation Testing

A planned suite of tests will be a requirement of the proposal to demonstrate the improvements of the new material and validate any life predictions. The full-scale tests should be representative of the operation of a geared turbofan application where practicable (e.g. rotating outer ring) and agreed with Rolls-Royce. The testing has been broken down in to the following work packages.

T2.1 - Sub-scale journal bearing rig test - Tribology
Primarily required for material characterisation of key properties including friction and wear.

T2.2 - Full-scale journal bearing rig tests - Fatigue and Endurance
Primarily required for material proving and model validation of key journal bearing operational characteristics including but not restricted to heat generation, oil flow, conductivity, and integrity. The testing should represent operation of a journal bearing in a comparable geared turbofan environment to demonstrate the scalability of the new material and manufacturing process. Tests include but are not limited to fatigue, endurance, start/stop, damage tolerance, and operational limits. All test details to be agreed with Rolls-Royce. Indicative limits as follows: Average Bearing Pressures up to 50MPa, Linear Speeds up to 60m/s.

T2.3 - Full scale journal bearing rig tests – Extreme Conditions

Primarily required to demonstrate material robustness while operating under extreme conditions. This includes but is not limited to operation under mixed friction, transient loads, start/stop, oil interrupt, and debris ingestion.

T2.4 - Full scale journal bearing rig test - Assembly Proving

Primarily required for demonstration of material robustness under assembly, transportation and storage. The testing should provide demonstrate limitations for all aspects of the component lifecycle outside engine operation.

T3 – Manufacture and Supply – Journal Bearing Components

The developed journal bearing material will require validation testing on R-R bearing and system rigs.

This will be in addition to the bearing rig tests described in WP 2. The Partner will be required to manufacture and provide journal bearing hardware to support Rolls-Royce bearing rigs, system rigs and whole engine demonstrator. The hardware quantities should be maximized within the proposed budget and timescale of the project to achieve maximum benefits in relation to the test objectives.

T3.1 - Rolls-Royce material/functional rig
Deliver journal bearing hardware with developed material for Rolls-Royce sub-scale bearing rig.

T3.2 - Rolls-Royce full-scale Orbiting Rig
Deliver journal bearing hardware with developed material for Rolls-Royce orbiting bearing rig.

T3.3 - Rolls-Royce PGB System Demonstrator

Deliver journal bearing hardware with developed material for Rolls-Royce PGB system demonstrator.

T3.4 - Rolls-Royce Whole Engine Demonstrator

Deliver journal bearing hardware with developed material for Rolls-Royce Whole Engine demonstrator.

T4 – Supporting Analysis & Assessment

Throughout the project analysis and assessment will be required to establish operational limitations of the developed journal bearing material in aero-engine applications and guide any future developments. A key development will be a lifing method for the developed journal bearing material in engine operation. All analysis, assessments, test results and conclusions will be documented and provided to Rolls-Royce.

T4.1 - Lifing methods for new material
Additional to the enhancement and development of materials it will be necessary to further develop the analysis tools and methodologies for component life prediction consistent with any material improvements and enhancements. The lifing method should include wear, fatigue and thermal behaviour under cyclic operation, start/stops, boundary lubrication and extreme conditions. Validation of the lifing method and analysis tool will be supported by results from test rigs covered in WP 2 & 3.

T4.2 - Quantify material improvement – life, operational limits
Operational limits and material characteristics are to be determined to support future designs and quantify the benefit of the developed material. These include but are not limited to load, speed, life, temperature, traction, wear rates.

T4.3 - Rig test data interpolation & analysis
To support the rig testing described in WP 2 & 3 all available data is to be collated and assessed. The assessments should provide conclusions over the material capabilities, rig operation and design. Interpolation of the results will be required supported by analysis to demonstrate applicability to the future engine applications.

T5: Project management

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:

- A number of progress reports and deliverables will have to be submitted 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 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 of the programme, exact schedule to be agreed at the beginning of the project.
- Status reports will be provided to Rolls-Royce on a yearly and quarterly basis to demonstrate progress of the project. All analysis, assessments, test results and conclusions will be documented and provided to Rolls-Royce in an agreed format.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D1.1	Define existing material boundary envelope	Deliverable	6 months
D1.2	Confirmation of material enhancement goals	Deliverable	9 months
D1.3	Identification and implementation of process and product changes	Deliverable	12 months
D3.1	Deliver Hardware – R-R material/functional rig	Deliverable	12 months
D3.2	Deliver Hardware – R-R full scale orbiting rig	Deliverable	18 months
D5.1	Project Review - to include a status report of the project that details the status of the deliverables, milestones, level of spend and dissemination.	Deliverable	18 months
D2.1	Sub-scale test results	Deliverable	24 months
D3.3	Deliver Hardware – R-R PGB system demonstrator	Deliverable	24 months
D1.4	Preliminary production capability based on sample delivery	Deliverable	36 months

Deliverables			
D1.5	Material Characterisation / Data for Design	Deliverable	36 months
D2.2	Full-scale test results	Deliverable	36 months
D3.4	Deliver Hardware – R-R whole engine demonstrator	Deliverable	36 months
D5.2	Project Review - to include a status report of the project that details the status of the deliverables, milestones, level of spend and dissemination.	Deliverable	36 months
D4.1	Lifing model for developed material	Deliverable	48 months
D4.2	Validation of improvements delivered by new material	Deliverable	48 months
D5.3	Final Management report (project closure): summarise the project management of the programme, including deliverables, level of spend and dissemination	Deliverable	48 months

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1.1	Determine existing material limitations	Report	6 months
M1.2	Material improvement requirements	Agreement	9 months
M1.3	Test plan requirements	Agreement	9 months
M1.4	Material characterisation strategy	Agreement	6 months
M1.5	Lifing analysis model strategy	Agreement	12 months
M3.1	Hardware for R-R material test	Product	12 months
M1.6	Hardware for characterisation	Product	18 months
M2.1	Hardware for tribological test	Product	18 months
M2.2	Tribological test of new material(s)	Report	18 months
M1.7	Down select material options for sub-scale test	Agreement	18 months
M3.1	Hardware for R-R orbiting rig	Product	18 months
M1.8	Characterisation of new material(s)	Report	20 months
M2.3	Hardware for sub-scale test	Product	20 months
M2.4	Sub-scale test results	Report	24 months

Milestones (when appropriate)			
M1.9	Down select material options for full-scale test	Agreement	24 months
M3.2	Hardware for R-R PGB System Test	Product	24 months
M2.5	Hardware for full-scale bearing test	Product	30 months
M1.10	Optimised manufacturing production process	Report	30 months
M1.11	Final material selection	Agreement	30 months
M2.6	Full-scale test results	Report	36 months
M1.12	Characterisation of final material	Report	36 months
M3.3	Hardware for R-R whole engine test	Product	36 months
M4.1	Validation of improvements to material	Report	48 months
M4.2	Validation of lifing model	Report	48 months
M1.13	Enhanced material suitable for production	Product	48 months
M4.3	Final Reports	Report	48 months

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

It is expected that a specific set of skills and facilities are required by the candidate and it is therefore expected that the response will address the following areas of expertise as a minimum.

- Established hydrodynamic bearing production manufacture in volume to regulated business sectors
- Hydrodynamic bearing materials and manufacturing process development including modelling and verification, heat treatment and surface engineering
- Experience of hydrodynamic bearing design and material development for operation under mixed friction and start/stop conditions
- Hydrodynamic bearing materials characterisation and evaluation including but not limited to material, mechanical and thermal properties
- Hydrodynamic bearing production and supply capability for series production
- A proven record of hydrodynamic bearing test facility management
- Hydrodynamic bearing test facilities to a standard that would be equivalent to Aerospace approved facilities, ideally with suitable quality certifications
- Hydrodynamic bearing test facilities capable as a minimum of the referenced tests. (Modification of test facilities to accommodate full scale component testing would be acceptable).
- A proven record for generating, post processing and interpreting hydrodynamic bearing test data
- Hydrodynamic bearing methods development including component lifing methodologies

XII. Development of capability to understand & predict sub-idle & idle behaviour of geared VHBR engines

Type of action (RIA or IA)	RIA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP 6 – VHBR – Large engine market		
Indicative Funding Topic Value (in k€)	1020		
Topic Leader	Rolls-Royce	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[67]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CFP06-ENG-03-18	**Development of capability to understand & predict sub-idle & idle behaviour of geared VHBR engines.**
Short description	
To develop capability to understand and predict sub-idle & idle behaviour of geared VHBR engines. Identify novel methods to model, manage & improve performance & operability at idle & sub-idle. Toolset to be matured to TRL6 by validation against test data collected from UltraFan™ demonstrator program.	

[67] 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 geared engine demonstrator (WP6 of Engine ITD) for large engine market. One of the key technologies required to meet the goals of WP6 is to develop the capability to predict sub-idle and idle performance & operability of a VHBR geared engine and be able to take it into account in the engine design.

The current understanding held by the topic manager is built current civil large engine (CLE) direct drive experience and has the following shortcomings with regard to geared VHBR products:

1) Future VHBR geared engines represent a significant change to sub-idle and idle behaviour due to the smaller core as a result of the high bypass ratio, introduction of staged combustion and change in architecture specifically to a lower speed Fan and inclusion of a PGB. Effects of these changes to sub-idle and idle performance & operability need to be understood.
2) VHBR geared engines have increased system complexity with compressor variable guide vanes, bleeds and more complex heat management system to manage the additional heat loads of the PGB. Effects of these changes to sub-idle and idle performance & operability need to be understood.
3) With VHBR geared engines there is a requirement to more accurately & reliably predict sub-idle & idle engine performance & operability specifically to help the design of:
    a. Optimised environmental protection system such as anti-ice/de-ice systems and those which extract water & particulates. These are made more challenging due to the lower pressures & temperatures through the Fan & IP compression system.
    b. Optimised heat management & fuel systems where it is important to have accurate fuel flow and heat loads. This is made more challenging to the additional heat load of the PGB and the larger amount of actuation on a VHBR geared engine.
    c. Optimised accessory gearbox design which is made more challenging due to the greater number of accessories being driven off the gearbox.
4) With VHBR geared engines the long HP spool means they are more susceptible to post shutdown distortion such as rotor bow. Understanding of sub-idle performance & operability is required to assess how this can be managed.

Future aircraft create a need to better understand idle performance & operability specifically:

- Improvements in aerodynamic efficiency create a requirement for lower idle thrusts in order to maximise environmental benefits and avoid deploying devices such as air brakes in descent. Capability is needed to look at how this can be achieved.
- Increasing power offtake demands from the aircraft make it more challenging to manage engine operability at idle. Capability is needed to understand the effect of this.
- There is a requirement for shorter start/stop times to improve aircraft turnaround. Understanding sub-idle behaviour is required to identify methods by which this can be achieved.

The current proposal is expected to deliver a 1d thermodyanmic toolset that has component performance understanding built into it and has the capability to predict sub-idle & idle performance & operability of geared VHBR engines.

The objectives of the current proposal are to:

1. Develop methods and techniques to predict compressor performance & operability at sub-idle and idle.
2. Develop methods and techniques to predict combustor sub-idle & idle performance & operability including ignition & extinction boundaries
3. Develop methods and techniques to predict LP system sub-idle & idle performance & operability specifically the Fan & cold nozzle performance.
4. Create a toolset that accurately and reliably calculates whole engine sub-idle & idle performance & operability.

2. Scope of work

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T1	Management	T0 + 36 months
T2	Compressor Performance & Operability	T0 + 24 months
T3	Combustor Performance & Operability	T0 + 24 months
T4	LP System Performance & Operability	T0 + 24 months
T5	Whole Engine Integration	T0 + 36 months

A brief description of the tasks is given below:

Task 1: Management

Organisation:

- Due to the range of skills required for this topic it is expected to require a number of partners working together.
- 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:

- Five 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 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: Compressor Performance & Operability

This task is to understand the characteristics of gas turbine axial compressors within a geared VHBR architecture at sub-idle & idle. Rig test data of existing compressors at sub-idle & idle will be provided. It is expected the partner(s) will apply numerical analysis to this data, understand how the compressors operate and develop a method to predict compressor performance & operbaility within a VHBR geared architecture. The method shall be scalable for different engine sizes. Effect of bleed and variable geometry should be considered and the method created should take this into account. The interaction of other gas path components should be taken into account and the method validated against VHBR geared engine test data provided by the topic manager.

Task 3: Combustor Performance & Operability

This task is to understand the performance & opeerability of staged combustors within a geared VHBR architecture at sub-idle & idle. Rig test data of combustors at sub-idle & idle will be provided. Numerical analysis using CFD should be used to produce the method. The effect of spray pattern & heat release on combustor performance & operability should be considered. Ignition & extinction models should be produced. Combustor attributes important for sub-idle & idle operation should be identified. The methods shall be scalable for different engine sizes. The methods should be validated against VHBR geared engine test data provided by the topic manager.

Task 4: LP System Performance & Operability

This task is to understand the sub-idle & idle performance & operability of the LP system in particular the low speed fan including Fan OGV and nozzle performance at these conditions. Fan intake interactions at idle and installation effects from the wing and aircraft on LP system performance should be considered. It is expected this work be done by use of 3D CFD using geometry assumptions agreed with the topic manager. The methods shall be scalable for different engine sizes. The methods should be validated against VHBR geared engine test data provided by the topic manager.

Task 5: Whole Engine Integration

This task is to bring together the methods developed as part of tasks 2,3, & 4 into a toolset that can be used to calculate whole engine performance at sub-idle and idle conditions. The toolset shall be scalable for different engine sizes. To do this task methods should also be developed methods for the remaining gas turbine components such as the air & heat management system that do not have their own workstream. It should be possible to run the toolset to simulate steady state points and also look at transient behaviour. In some areas it is expected the methods developed by the other workstreams will require simplification in order to be combined. The toolset should be created in NPSS or as a minimum be compatible with it to allow it to be integrated with the topic manager's existing key tools. It shall be validated against VHBR test data provided by the topic manager. The toolset shall be tested to make sure it is repeatable & reliable.

NPSS is an object-oriented, multi-physics, engineering design and simulation environment that enables development, collaboration and seamless integration of system models. More information can be found at: http://www.swri.org/npss/

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type****	***Due Date***
D1	Project Annual Review: to include a status report of the project that details the status of the deliverables, milestones, level of spend and dissemination.	Report	T0 + 12 months
D2	Axial compressor sub-idle & idle method: report summarising method selected & developed to predict compressor sub-idle & idle behaviour	Report	T0 + 24 months
D3	Combustor sub-idle & idle method: report summarising methods developed to predict compressor sub-idle & idle behaviour	Report	T0 + 24 months
D4	LP System Sub-Idle & Idle Method: report summarising methods developed to predict LP system sub-idle & idle behaviour	Report	T0 + 24 months
D5	Project Annual Review: to include a status report of the project that details the status of the deliverables, milestones, level of spend and dissemination.	Report	T0 + 24 months
D6	VHBR geared engine sub-idle & idle performance toolset: demonstration of tool(s) to topic manager and report summarising how it works and used	Report / Data	T0 + 33 months
D7	Tool Validation: report summarising tool validation & evidence of reliability	Report /Data	T0 + 36 months
D8	Final Management report (project closure): summarise the project management of the programme, including deliverables, level of spend and dissemination	Report	T0 + 36 months

*Types: R=Report, D-, HW=Hardware

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type****	***Due Date***
M1	Management Report: summarise the project management of the programme, including deliverables, level of spend and dissemination	Report	T0 + 36 months
M2	Component methods selected: completion of component method development with deliverables D2, D3, D4 achieved	Reports	T0 + 24 months
M3	VHBR sub-idle & idle toolset delivered: report summarising how toolset works and is used together with validation evidence. Deliverables D5 & D6 achieved	Reports/ Data	T0 + 36 months

*Types: R=Report, D-Data, HW=Hardware

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

- Experience in the following topic areas or ability to partner with a suitable organisation that has the relevant experience
- Experience in gas turbine performance modelling using 1d thermodynamic code and ability to simulate gas turbine components using theoretical tools.
- Experience in the use of Systems Engineering tools & concepts.
- Experience in gas turbine compressor aero design and ability to model.
- Experience in gas turbine combustor design and ability to model.
- Capability to investigate engine-aircraft installation effects using CFD.
- Experience in creating software toolsets for use in aerospace industry.

5. Abbreviations

CFD	Computational Fluid Dynamics
CLE	Civil Large Engine
LP	Low Pressure
HP	High Pressure
NPSS	Numerical Propulsion System Simulation
OGV	Outlet Guide Vane
VHBR	Very High Bypass Ratio

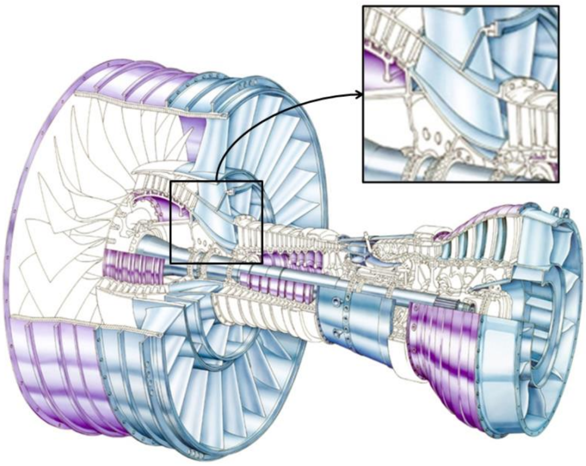
XIII. Intermediate Compressor Case Duct Aerodynamics

Type of action (RIA or IA)	RIA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP 6: VHBR – Large Turbofan Demonstrator UltraFan™		
Indicative Funding Topic Value (in k€)	500		
Topic Leader	GKN	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	30	**Indicative Start Date**[68]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CFP06-ENG-03-19	**Intermediate Compressor Case Duct Aerodynamics**
Short description	
An experimental test campaign is planned to be performed to verify that the design of the demonstrator ICC performs as predicted. In a second test campaign new technologies and innovative duct designs will be studied. The duct flowfield will be characterized in detail in order to provide validation data for CFD methods. Off-design performance will be of specific interest to this exercise. Development of CFD tools, including more advanced modelling techniques (such as hybrid LES methods) will be an important task to be able to predict part-speed performance and separation margin of the ICC duct.	

[68] The start date corresponds to actual start date with all legal documents in place.

1. Background



The drive for environmental improvements in air transport in combination with increasing global competition on all supplier levels in the aero engine business gives a need for innovation in engine architecture and improvement in component design for enhanced engine performance. The efficiency of modern turbofan engines is improved by splitting the compression system into two parts; a low/intermediate-pressure compressor and a high-pressure compressor. The intermediate compressor case (ICC) connects the two, and is also a structure providing engine mounts. Hence the ICC is subject to strict structural requirements. For radial stiffness and bearing support, struts with aerodynamic shape are placed in the flowpath. In addition to their structural support, the ICC struts also serve as passages for oil and air transport. Aerodynamically the ICC connects the two compressors via an S-shaped transition duct in order to accommodate the difference in radius. The Topic Manager is developing innovative ICC technology for a new Very High Bypass Ratio (VHBR) engine architecture. Selected technologies will eventually be demonstrated in full scale engine tests.

For the new generation of VHBR engines there will be a need for more compact and aggressive ICC ducts with an increased emphasis on operability aspects. The low/intermediate-pressure compressor rear end design needs to integrate the aerodynamics for performance with the bleed to extract ice, particles and water more closely. Choices pertaining to the extraction of particles include whether the bleed port be placed directly at the last rotor trailing edge or at a location downstream of the last stator. The effectiveness of the extraction is critical, since only low pressure differences are possible under certain operating conditions. At the same time the losses incurred and effects on the core flowpath aerodynamics will affect the duct flowfield and high-pressure compressor distortion.

A good aerodynamic design of the ICC duct and struts is crucial for achieving a low pressure loss, acceptable upstream distortion and a well-behaved inflow to the high-pressure-compressor. There are also important aspects associated with part-speed operability and an efficient particle extraction for safe operation under certain flight conditions. The research will be performed in close collaboration with the Topic Manager covering all aspects of the work; aerodynamic design, mechanical design, test setup and requirements, post-test analysis, CFD setup and objectives, etc.

2. Scope of work

The work scope can be split into two streams; experimental and numerical. The experimental part of the work proposed is split into two separate test campaigns:

1. Large Turbofan Demonstrator UltraFan™ ICC aerodynamics validation
    a. A compressor stage and duct representative of the proposed UltraFan™ ground test demonstrator IP compressor rear-stage and ICC duct is tested without bleed.

   b. A representative bleed port is added on the outer casing upstream of the compressor to study bleed/duct interaction, to capture the efficiency impact and to assess extraction capability.
2. Future UltraFan technology demonstration and validation
   a. A second design solution optimized for a more effective bleed extraction and/or lower impact on system performance and stall margin. Potentially also introducing a new duct design, more representative of a future UltraFan™ ICC.

It is of significant importance that necessary flowfield details can be resolved and that duct total pressure losses can be assessed based on the test data acquired. It is also important that the experimental data can be used to verify the duct design robustness in terms of stall/separation margin. Tests could be performed in a low-speed test rig, but need to cover the following operating conditions:

- ADP: $\Phi \sim 0.6$ and $\Psi \sim 0.3$
- Robustness with respect to flow coefficient: $0.55 < \Phi < 0.65$ (at least 3 throttle settings)
- Robustness with respect to bleed: 0-20% mass extraction (at least 5 bleed off-take settings).

The test should be designed to include the following instrumentation:

- Duct inlet and exit traverse using miniature 5-hole probe covering a complete strut pitch (36-45 deg depending on final strut count) is required.
- Test section inlet conditions are to be meassured using 3- or 5-hole probe radial traverse.
- Hot-wire traverse at test section inlet, to determine turbulence boundary conditions for CFD.
- Static pressure around the circumference close to rotor TE and stator TE is to be mapped.
- Duct/strut surface statics.

The experimental data will be used for validation of Topic Manager CFD tools and to establish proper correlations from CFD to design data. Finally the data will also be used to establish an advanced numerical analysis approach for compressor ducts. From a numerical perspective a literature survey and an analysis of the research frontier in advanced CFD modeling techniques will be performed to establish a starting point for the future work in the project. A selection of promising approaches to CFD modeling of compressor ducts including neighboring component interaction and particle tracking methods will be evaluated. At least one approach based on hybrid RANS/LES is to be investigated in detail for analysis of the complete test section (compressor stage, bleed and duct). The objective is to propose an advanced, yet efficient CFD approach for increased numerical accuracy, reasonable analysis turn-over time and robust performance. CFD analyses are to be performed at ADP and at a series of bleed off-take operating conditions (at least 3 off-take settings) to determine the duct stall/separation limit/margin.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T0.1	Management • The Partner shall nominate a team dedicated to the project and should inform the Topic Manager about the name/names of key personnel. • The Partner shall work to the agreed time-schedule and work package description. The time-schedule and the work package description outlined in section 3 of this Call shall be further detailed as required and agreed during negotiation based on the Partner's proposal. • 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 (face-to-face, Webex, link-call, etc.) shall be scheduled and held.	M30
T1.1	Build 1 test object design • Mechanical design of all test objects is to be performed by Partner. • Aero-design of duct will be supplied by Topic Manager. • Aero-design of the bleed system will be developed by the Partner in close collaboration with the Topic manager. • Aero-design of the compressor stage will be supplied by Topic Manager.	M12
T1.2	Manufacture of test build 1 • The Partner is responsible for CAD models and/or drawings required for procurement and manufacturing of the necessary rig hardware to perform the test. • The Partner is responsible for manufacture/purchase of the test hardware. • Aero-surface manufacturing quality should meet a profile tolerance of ±0.1 mm and surfaces roughness Ra~1 µm.	M15
T1.3	Test of build 1 • The aerodynamic testing shall be performed in accordance with the Partner's previous experience and according to established best-practice. • Instrumentation and test matrix shall be in accordance with details outlined earlier in Section 2.	M24

Tasks		
T2.1	Build 2 test object design • Aero-design of the build 2 test object is to be developed in close collaboration with the Topic Manager. • Mechanical design (CAD) of the test objects is to be performed by the Partner.	M21
T2.2	Manufacture of test build 2 • The Partner is responsible for CAD models and/or drawings required for procurement and manufacturing of the necessary rig hardware to perform the test. • The Partner is responsible for manufacture/purchase of the test hardware. • Aero-surface manufacturing quality should meet a profile tolerance of ±0.1 mm and surfaces roughness Ra~1 µm.	M24
T2.3	Test of build 2 • The aerodynamic testing shall be performed in accordance with the Partner's previous experience and according to established best-practice. In addition any lessons-learned from build 1 testing shall be considered.	M30
T3.1	Explore advanced CFD approach alternatives • The Partner should perform a literature survey and a review of the global research frontier of LES-type simulation approaches that could be suitable for compressor duct CFD. The focus should be on numerical accuracy, method robustness and speed.	M6
T3.2	Advanced CFD analysis • Code development in terms of numerical schemes, boundary conditions, feature detailing, efficient programming, industrialization of software, etc.	M30
T3.3	Advanced CFD recommendations and guidelines • The Partner will establish best-practices for advanced CFD analysis of integrated compressor duct aerodynamics and CFD tools will be developed in accordance with these guidelines. • The Partner shall provide Topic Manager with code and instructions for performing advanced CFD analysis in accordane with proposed guidelines.	M30

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D0.1	Project management plan - detailed schedule, description of team structure and communication plan.	R	M3

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1.1	Design of test build 1 – complete CAD model of test object, including compressor and duct	D	M12
D1.2	Manufacture of test build 1	HW	M15
D1.3	Test of build 1 – data set and experimental report	D, R	M24
D2.1	Design of test build 2 – complete CAD model of test object, including compressor and duct	R	M21
D2.2	Manufacture of test build 2	HW	M24
D2.3	Test of build 2 – data set and experimental report	D, R	M30
D3.1	Selected CFD methods for further exploration – literature survey and well-documented down-select of methods being explored further including initial CFD results (using suitable existing test case or build 1 data for validation)	D, R	M6
D3.2	Build 1 & 2 CFD analysis – selected sub-set of CFD data and analysis report	D, R	M30
D3.3	CFD recommendations for compressor ducts – proposed numerical method and guidelines for analysis of compressor ducts taking accuracy, speed and robustness of method into account	R	M30

*Types: R=Report, D=Data, HW=Hardware, ECM=Engineering coordination memo

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1.1	Rig commissioning for test build 1	ECM	M18
M1.2	Completion of build 1 testing	ECM	M21
M2.1	Rig commissioning for test build 2	ECM	M24
M2.2	Completion of build 2 testing	ECM	M27
M3.1	Final CFD analysis of build 1	R	M24
M3.2	Final CFD analysis of build 2	ECM	M30

*Types: R=Report, D=Data, HW=Hardware, ECM=Engineering coordination memo

All tasks, deliverables and milestones are represented graphically in this overall time-schedule.

Tasks/Deliverables/Milestones		2018				2019				2020	
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
		M1-M3	M4-M6	M7-M9	M10-M12	M13-M15	M16-M18	M19-M21	M22-M24	M25-M27	M28-M30
Ref. No.	**Title**										
T0.1	Management	D0.1									
T1.1	Build 1 test object design				D1.1						
T1.2	Manufacture of test build 1					D1.2					
T1.3	Test of build 1						M1.1	M1.2	D1.3		
T2.1	Build 2 test object design							D2.1			
T2.2	Manufacture of test build 2								D2.2		
T2.3	Test of build 2								M2.1	M2.2	D2.3
T3.1	Explore advanced CFD approach alternatives		D3.1								
T3.2	Advanced CFD analysis								M3.1	M3.2	D3.2
T3.3	Advanced CFD tool and guidelines										D3.3

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

- The CfP Partner/consortium should have a proven track-record in duct aerodynamics experimental and numerical research. In particular the Partner should have experience in detailed flowfield meassurements and experimental loss assessment in compressor ducts.
- The CfP Partner/consortium should have access to a single-stage compressor test facility suitable for duct integration and testing. The compressor should be operating at representable low/intermediate-pressure compressor rear-stage conditions. Based on pre-studies this implies flow coefficient 0.55 < Φ < 0.65, work coefficient Ψ ~ 0.3 at ADP and a hub-to-tip ratio of about 0.85. The preliminary duct non-dimensional characteristics are L/Hin ~ 3.6, ΔR/L ~ 0.6 and Aout/Ain ~ 1. To perform the necessary loss meassurements with sufficient accuracy it is estimated that the compressor exit radius needs to be >200 mm and the duct height >40 mm. For a low-speed test facility it is estimated that this setup would require a 50 kW motor and an additional 20 kW motor for the bleed extraction.
- The CfP Partner/consortium should have knowledge and experience of turbomachinery aerodynamics and system level knowledge of aero engines.
- The CfP Partner/consortium should have experience in development of in-house codes for compressible flow simulation.
- The CfP Partner/consortium should be involved in ongoing research on advanced CFD methods for turbomachninery, in particular for compressors and ducts with focus on validation in close collaboration with an experimental research partner/organisation.
- The CfP Partner/consortium should have experience in mechanical design for the test facility.
- The CfP Partner/consortium should have the necessary manufacturing capability and experience of compressor and duct test objects.
- The CfP Partner/consortium should have a profound knowledge within the fields of turbulence modelling and particularly hybrid RANS/LES methods.
- Experience in performing applied collaborative industrial research in international environment is considered essential.

5. Abbreviations

ADP	Aerodynamic Design Point
CFD	Computational Fluid Dynamics

ICC	Intermediate Compressor Case
LES	Large Scale Eddy (simulation)
RANS	Reynolds-Averaged Navier-Stokes
VHBR	Very High Bypass Ratio

XIV. Advanced investigation of ultra compact RQL reverse flow combustor

Type of action (RIA or IA)	IA		
Programme Area	ENG/SAT		
Joint Technical Programme (JTP) Ref.	WP 8.4 – Advanced Combustor Technology		
Indicative Funding Topic Value (in k€)	600		
Topic Leader	AVIO	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	18	**Indicative Start Date**[69]	Q1 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CFP06-ENG-04-07	**Advanced investigation of ultra compact RQL reverse flow combustor**
Short description	
Extremely compact reverse flow combustor architectures are required for future turboprop engines development, where geometry and space saving are strictly linked to fuel burn and emission reduction. The target of the CfP is to adapt the available Quick-Design-Rapid-Validation methodology to this family of combustors. Design-for-additive, Virtual combustor simulation and advanced diagnostic testing, addressed to innovative architectures and cooling concepts, quick quench modules design and low soot production, shall be developed to support in a period of 18 months the achievement of the objective. Strong collaboration among the possible partners and focus on available rigs is a strong requirement of the project.	

[69] The start date corresponds to actual start date with all legal documents in place.

1. Background

A growing European Union and economic development of emerging economies, e.g. the BRIC[70] states, increases the demand for interregional travel. However most of these routes are still low density traffic and the vast majority of the traffic on these routes is carried out by automotive means. This means of transportation cannot fulfil the core societal demand to achieve a door-to-door trip time within 4 hours in Europe (see Strategic Research and Innovation Agenda SRIA[71]). Only direct connections using Small Air Transport (SAT), i.e. aircraft application with up to 19 passengers, can support this goal. The SAT category has a significant potential to address the connections in these shorter routes with higher integration into the efficient transportation system by reducing the distance to be travelled on ground, i.e. to reach the airport or the destination from the airport respectively. Hence, SAT could be one important part of a future European environmentally friendly multimodal transport system.
A significant potential growth for the Small Aircraft Transport (i.e. Low Capacity Air Transportation) market is therefore expected, but strongly dependent on **highly efficient, highly reliable** aircraft. One of the key challenges therefore is to provide reliable and efficient power plants for the SAT market allowing longer time-on-wing, significantly reduced operating costs and easy maintainability.
The ITD-WP8 MAESTRO overall objective translates to the development, manufacturing and testing of a new and improved engine for the SAT market for up to 19 passenger aircraft applications. By these means the following four technical/societal objectives will be achieved:

	Objective
HLO.1	Up to 15% of fuel efficiency improvement vs. 2014 reference engine
HLO.2	Up to 10% of reduction of total operating costs vs. 2014 reference engine
HLO.3	Contribute to analysis of a noise reduction including propeller by 10 dB
HLO.4	Contribute to the achievement of the SRIA 2050 NO_x reduction target
HLO.5	Strengthen European competitiveness in Small Air Transport turboprop engines market

Table 3: High-Level Objectives

The described objectives for the overall system enhancement of fuel efficiency improvement, the extension of service life between overhauls and noise reduction will be achieved by sub-system technology development delivering the individual component efficiency improvements.
High compressor pressure ratio with high efficiency through operation envelope is basic factor for reaching the engine SFC goal. An axial-radial compressor architecture is mainly used in this engine class, focus of MAESTRO program is on highly loaded multistage axial compressor section.
Together with compressor pressure ratio the turbine entry temperature is one of the most important turbine engine cycle parameters directly influencing engine SFC. Continuous efforts for specific fuel consumption reduction require permanent engine development towards higher temperatures. Application of higher turbine entry temperatures impacts a wide range of gas generator parts. Magnitude of temperature increase must be therefore very carefully studied with regard to complex influence on performance and service life parameters.
The influence of raised temperature on combustor parts can also not be neglected and suitable modifications of its cooling system will be studied.

[70] In economics, BRIC is a grouping acronym that refers to the countries of Brazil, Russia, India and China, which are all deemed to be at a similar stage of newly advanced economic development (source: http://en.wikipedia.org/wiki/BRIC)
[71] Strategic Research and Innovation Agenda: Realising Europe's Vision in Aviation. Vol. I (September 2012). For details please see here: ftp://ftp.cordis.europa.eu/pub/technology-platforms/docs/sria-volume-1-final.pdf

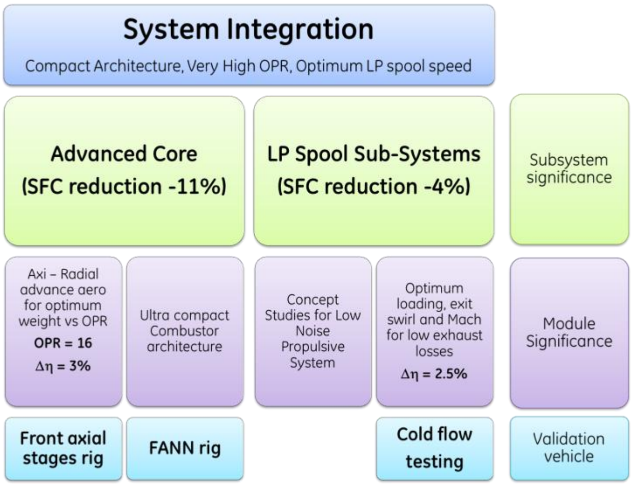


Figure 17: MAESTRO objectives breakdown

Therefore the required improvement in SFC has to be obtained with an appropriate balance between thermal & propulsive efficiency. The initial target split has been assigned the following goals:

- Advanced core SFC reduction: -11%
- LP spool sub system optimization: SFC reduction: -4%

To achieve these challenging goals the appropriate technologies have to be incorporated in the design of engine modules (compressor, combustor, turbines) to cope with the engine cycle requirements.

The overall MAESTRO project objective on the combustor area is two–fold: on the one hand, MAESTRO addresses the development of the Ultra Compact (UC) combustor configuration to an increased thermodynamic cycle, with high air inlet pressure and temperature. On the other hand, the use of Additive Manufacturing technologies will be massively used in order to verify their potential exploitation for the turboprop engine combustor size and cost.

The MAESTRO work plan is divided in two main phases: the first one is the development and manufacturing of **Ultra Compact Combustor** components and overall module validation via lab investigation and Full Annular Combustor testing at representative engine conditions.
The validation phase will be completed at the end of the 2016 in order to provide experimental results for the next design phase.
The produced database will support the tuning of the available design tools and the development of new numerical modeling (ignition, soot production, conjugate heat transfer).
All the research activity will be supported by the Quick Design and Rapid Validation (QDRV) methodology developed in previous EC funded programs (TECC, IMPACT, NEWAC, LEMCOTEC) for Lean Burn injection systems and effusion cooled liners. The QDRV technology, which makes significant use of Model Based Design philosophy and Additive Manufacturing prototyping, will be exploited to speed-up the development process and in the long run to lower the product cost.
According to that, in the second Phase of the MAESTRO program starting from the beginning of 2017 will be focused on a complete full-additive combustor configuration. An intensive preliminary study will be performed in order to develop new features to improve the cooling system and the overall

performance of the combustor leveraging on the degrees of freedom provided by the additive manufacturing technology.
A full additive combustor prototype will be manufactured by Topic Manager in order to complete the development process started at the beginning of the project and demonstrate the real feasibility of additive manufacturing technology. A third phase will be necessary to demonstrate and validate the additive combustor overall performance compared to the traditional one.

The objective of this Call for Proposal is to complete the validation process of the **full additive combustor with a full annular combustion test** at real engine conditions coupled with an high fidelity numerical modeling validation to be done by the Applicant.

The Topic manager will provide to the Applicant a full additive combustor prototype and a dedicated rig (with rotating probe) to complete the full annular combustion test.
The main characteristics of the rig are:
- Compact rig (2600 mm x 1100 mm x 1000 mm)
- Cold Water cooling line (demineralized water mandatory, up to 10 bar)
- Hot Water cooling line (demineralized water mandatory, up to 30 bar)
- Rotating Probe water cooled (demineralized water mandatory, up to 10 bar)
- Fuel type: JetA and max pressure up to 60 bar
- Inner and outer combustor dedicated bleed ports

The maximum operating conditions expected during the full annular test are:
- Inlet air Pressure: 16 bar
- Inlet air temperature: 790 K
- Inlet air mass flow: 4 Kg/s

The instrumentation will be applied on the combustor and the rig by the topic manager, and will consist in a certain number of sensors in order to collect the following parameters:
- static pressure
- total pressure
- static air temperature
- total air temperature
- metal thermocouples
- advance instrumentation on Applicant proposal

An advanced instrumentation has to be proposed and applied by the applicant for metal temperature monitoring. A detailed instrumentation list will be provided to the applicant with a dedicated deliverable.

Moreover together with the rig will be provided a dedicated rotating probe necessary to acquire emission measurements (CO, UHC, CO_2, NO_x, Smoke) and combustor exit gas temperatures.

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

The applicant will perform a number of tasks using a phase and gate approach. The topic manager will periodically meet the applicant in person or via teleconference in order to accurately track the evolution of the tasks.

The applicant shall perform the following tasks:

1. Task 1: Full Additive Combustor - Preparation Phase

- T.1.1 Input Information

  In this task all the input information will be responsibility of the topic manager that will provide to the applicant the following basic information:

  - Configuration of the full additive combustor [CAD model]
  - Configuration of the rig necessary for the FANN Tests [CAD model, RIG interfaces]
  - Test matrix with the main cycle parameters
  - Instrumentation list

- T.1.2 Test Prediction CFD Simulation

  This task will be the responsibility of the applicant that, using appropriate simulation tools and its engineering experience, will provide to the topic manager a detailed computational fluid dynamic simulation of the combustor assembled in to the rig with a coupled thermal prediction of the metal temperature of the combustor liners. LES approach preferable, but also RANS can be applied, depending on Applicant experience and available resources. In both cases, the Applicant have to demonstrate the accuracy of the proposed approach, on the basis of past experience on similar applications.

  The topic manager will require the test prediction simulations in two test point, one at low power (Ground Idle) and one at max power (Max Takeoff). The points selected will be identified in the test matric provided in task 1.1

  The information collected from the computational analysis will be used during the test campaign, in order to evaluate the measurement quality and the combustor behaviour.

  The main parameters that have to be considered during the test prediction phase are:

  - pattern factor and profile factor at the exit section of the combustor
  - emissions (CO, UHC, NOx, Smoke)
  - combustion efficiency
  - liners metal temperature

  The topic manager will approve and concur to the simulation set up and results discussion.

- T.1.3 Innovative Numerical Models Development

  This task will be responsibility of the applicant that, in parallel to the test execution, have to develop an innovative high fidelity model in order to correctly simulate the combustor behaviour in terms of performance (pattern factors, emission, efficiency) and liners metal temperatures. In this phase the applicant shall develop innovative models using advanced CFD technique like LES, SAS, DDES or URANS coupled to methodologies dedicated to heat transfer simulation.

The model will be the reference for the validation phase (Task 3), and it will be used for the comparison between the numerical results and the experimental data.

2. Task 2: Full ANNular Combustion Test

In order to demonstrate the feasibility of the full additive combustor design a full annular combustion test has to be performed in order to evaluate the overall combustor performance.

- T.2.1 Input Information for Lab Preparation

  The topic manager will provide:

  - **Rig hardware; adaptations to facility will be designed and manufactured by the applicant**
  - CAD model of the rig with actual interfaces [CAD model, rig interfaces]
  - Test matrix with the main cycle parameters
  - Instrumentation preinstalled on the rig

- T.2.2 Test Specification

  Based on input provided in task 2.1 the applicant shall propose a test specification (operative instruction) and a test plan to the topic manager, in order to demonstrate the capability of the test cell to execute correctly all test points defined in the test matrix and acquire all measurements required by the topic manager.

  During the test campaign will be expected the acquisition of the following measurements:

  - static pressure
  - total pressure
  - static air temperature
  - total air temperature
  - metal thermocouples
  - emissions concentrations
  - exit gas temperature using rotating probe
  - Advanced instrumentation proposed by the applicant (see next task)

  The detail of the instrumentation list will be provided at the beginning of the project

  The topic manager will approve the test plan and procedure defined by the applicant.

- T.2.3 Test Campaign - Lab Preparation

  In parallel with the test specification preparation (T2.2), the applicant has to start all activities required to set up the test facility and the test cell in order to perform the test campaign required by the topic manager. In particular, in case of discrepancy between the rig and the facility interfaces, the applicant will design the adaptations between the Rig and the facility and will perform engineering evaluation on the design choice.

In addition to that, the Applicant shall propose any additional instrumentation needed for the validation of the model developed in previous tasks and consistent with the rig definition (an optical access will be available on the rig for the purpose). After acceptance of the Topic manager, he will provide the additional instrumentation and will apply on the test article.

The topic manager will review the Lab preparation activity proposed by the applicant in order the check the compliance with the topic objective. The review will assess: adaptation design, experimental measurements capability, maximum number / type of prolongation cables and sensors, test cell acquisition system accuracy, cooling rig requirements and facility capability.

- T.2.4 Test Execution

  This task will be responsibility of the applicant and will be divided in two main phases. The first one dedicated to the installation of the rig (using dedicated interfaces if necessary) and the test article (full additive combustor) in the test cell.

  The second phase will be the execution of the combustion tests following the test matrix and test specification prepared at the beginning of the project.

  During the test campaign all parameters necessary to evaluate the overall performance of the combustor (pressure, mass flow, temperature, emissions, and metal temperatures) have to be acquired, stored and provided to topic manager.

  Duration of the productive test day is approximately 10-15 days. Considering 60 minutes as the average time needed for acquiring SS points and 5 hours of productive time per day, a minimum number of 60 acquisition points or any combination of that, is required.

3. Task 3: Full Additive Combustor - Validation Phase

After the completion of the test campaign a detailed validation phase will be required in order to correlate the test results with the combustor design intent.

- T.3.1 Experimental Results Elaboration

  In this task the applicant shall collect all data acquired during the test campaign and perform a preliminary elaboration in order to highlight the main combustor behaviour in terms of aerodynamic performance and overall metal temperatures.

  The applicant shall deliver to the topic manger, a final test results report with all information collected during the test campaign and the elaboration performed during the task.

- T.3.2 Numerical Model Tuning and Validation

  Starting from the numerical models used for the test prediction phase, the applicant shall perform a comparison between the results obtained from the numerical models and the experimental tests.

  A validation and tuning activity have to be completed on the numerical models (fluid dynamic models and heat transfer models) in order to align the simulation results to the experimental data.

The activity has to be performed at least on two test points as done in Task 1.2 during the test prediction phase. The selection of the two experimental points will be shared and agreed with the topic manager.

The applicant – after the complete models has been revised and validated – will provide to the topic manager the full CFD model (mesh, macros for applying boundary conditions and post-processing and any procedure developed to perform the simulation) and the detailed thermal model coupled to a detailed report with the simulations performed and the numerical and experimental comparisons.

Tasks		
Ref. No.	***Title – Description***	***Duration***
T1	**Full Additive Combustor - Preparation Phase**	**Mo1-Mo12**
T1.1	Input information (Topic Manager)	Mo1-Mo1
T1.2	Test Prediction - CFD Simulation	Mo2-Mo4
T1.3	Innovative Numerical Models Development	Mo5-Mo12
T2	**FANN Test**	**Mo1-Mo7**
T2.1	Input Information for Lab Preparation (Topic Manager)	Mo1-Mo1
T2.2	Test Specification	Mo2-Mo3
T2.3	Test Campaign - Lab Preparation	Mo2-Mo3
T2.4	Test Execution	Mo3-Mo7
T3	**Full Additive Combustor - Validation Phase**	**Mo7-Mo18**
T3.1	Experimental Results Elaboration	Mo7-Mo12
T3.2	Numerical Model Tuning and Validation	Mo13-Mo18

Mo: month from T0

3. Major deliverables/ Milestones and schedule (estimate)

	Deliverables			
Ref. No.	***Title - Description***	***Owner***	***Type (*)***	***Due Date***
D1	Overall Input Information	Topic Manager	R	T0+1 months
D2	Test Prediction Results	Applicant	R	T0+4 months
D3	Test Specification	Applicant	R	T0+3 months
D4	FANN Test Experimental Results	Applicant	R	T0+13 months
D5	Innovative Numerical Models Description	Applicant	R	T0+13 months

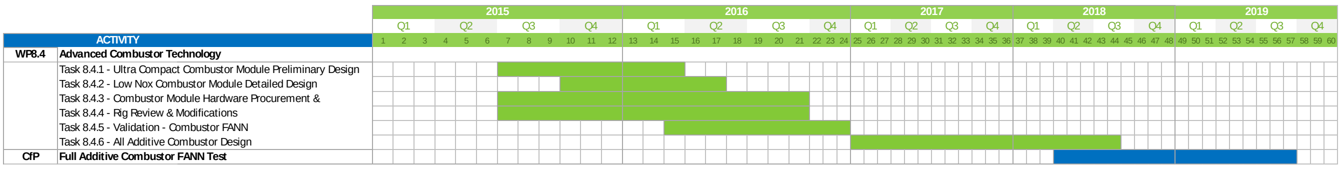
D6	Numerical models validated	Applicant	R	T0+18 months

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

	Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Owner***	***Type***	***Due Date***
M1	Test facility and Test cell ready	Applicant	D	T0+3 months
M2	Delivery Test Article and Rig	Topic Manager	D	T0+3 months
M3	Full Annular test completion	Applicant	R	T0+7 months
M4	CFD validated model	Applicant	D	T0+18 months

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

<u>For information overall demonstrator schedule:</u>



<u>Schedule for Topic Project (Level 2 Gantt):</u>

		2018									2019											
		Q2			Q3			Q4			Q1			Q2			Q3			Q4		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
ACTIVITY																						
Task 1	**Full Additive Combustor - Preparation Phase**																					
	T.1.1 - Input information (Avio)																					
	T.1.2 - Test Prediction - CFD Simulation																					
	T.1.3 - Innovative Numerical Models Development																					
Task 2	**Full ANNular Test Campaign**																					
	T.2.1 - Input Information for Lab Preparation (Topic Manager)																					
	T.2.2 - Test Specification																					
	T.2.3 - Test Campaign - Lab Preparation																					
	T.2.4 - Test Execution																					
Task 2	**Full Additive Combustor - Validation Phase**																					
	T.3.1 - Experimental Results Elaboration																					
	T.3.2 - Numerical Model Tuning and Validation																					

		2018									2019											
		Q2			Q3			Q4			Q1			Q2			Q3			Q4		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
PROJECT DELIVERABLES																						
D1	Overall Input Information	D1																				
D2	Test Prediction Results				D2																	
D3	Test Specification			D3																		
D4	FANN Test Experimental Results													D4								
D5	Innovative Numerical Models Description													D5								
D6	Numerical models validated																		D6			

		2018									2019											
		Q2			Q3			Q4			Q1			Q2			Q3			Q4		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
PROJECT DELIVERABLES																						
M1	Test facility and Test Cell ready for test			M1																		
M2	Delivery Rig and Test article			M2																		
M2	Delivery Rig and Test article							M3														
M3	Full Annular Test completion																		M4			

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

- Computational Fluid Dynamic simulation:

  Extensive experience in applying CFD modelling on combustion chamber for aerospace application. Proven experience in numerical and experimental data matching by detailed CFD combustion models and multi-hole liner cooling models.

  Experience in managing experimental data from rotating probe is an asset.

  Successful experience, with demonstrable benefits, in the application of innovative numerical methodologies to correctly simulate the combustion flow field, taking into consideration cooling flow coupling for multi-holes liners and its impact on performances.

  Proven capacity of performing numerical assessments in both predictive and validation phase, applying the above CFD techniques, with no impact in term of task delay / milestone shift.

- Heat transfer simulation:

  Extensive experience in developing detailed numerical model for liners thermal behaviour prediction of combustion chamber for aerospace application.

  Successful experience of applying innovative numerical methodologies to correctly simulate the fluid dynamic and heat transfer phenomena of multi-hole liners.

  Capability of modifying those models and to adapt them for the configuration proposed by the Topic manager. Provide experimental validation of the proposed approach.

  Experience in managing experimental data from conventional metal temperature instrumentation and, optionally, not-intrusive innovative techniques.

  Fundamental is a proven experience in cooling flow field and heat transfer simulations in order to correlate experimental metal temperatures with the predictive tool results.

  Proven capability of performing numerical assessments in both predictive and validation phase, applying the above techniques, with no impact in term of task delay / milestone shift.

- Testing:

  The Applicant will demonstrate of having available test cell capable of meeting the requirements of the Topic goals, in particular test conditions in terms of inlet air temperature and pressure, water cooling and fuel lines at the required level of flow and pressure.

  Successful experience, with demonstrable benefits, of Full Annular combustion test on high performance combustion chamber for aerospace application or equivalent. In particular availability of consolidated methodologies and capabilities to collect the measurements necessary to assess the performances of a combustion chamber are an asset.

- Intellectual Proprieties

  The applicant have to demonstrate of having an adequate process in order to guarantee to the topic manager a proper IP protection and IP management, in particular referring to the hardware, the CAD models and the test results provided by the topic manager to the applicant.

The advanced CFD models developed during the project and validated using the the experimental data will be shared between the Topic manager and the applicant. A dedicated process will be put in place in order to manage properly the IP related to advanced models developed

- Experience in aerospace R&T and R&D programs.

Special Skills:

- Experience in Supply Chain management (for Test facility and Test cell preparation)
- Experience in experimental testing and Statistical Methodologies (for Test Plan definition and execution and experimental data management).

6. Clean Sky 2 – Systems ITD

I. Manufacturing process for ultimate performance inertial MEMS accelerometer

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP1		
Indicative Funding Topic Value (in k€)	1500		
Topic Leader	Thales Avionics	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[72]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-SYS-01-04	**Manufacturing process for ultimate performance inertial MEMS Accelerometer**
Short description	
In the context of the Modular Advanced Inertial System Development, the introduction of Silicon Very High Performances MEMS Accelerometers Technology is targeted. Based on an existing design, the challenge of the topic is to develop an industrial Silicon MEMS manufacturing process to meet the performances, reliability and reproducibility level required by inertial systems applications.	

[72] The start date corresponds to actual start date with all legal documents in place.

1. Background

The integration of MEMS accelerometer sensors into multi axis Inertial Measurement Units is required in order to allow for the widespread dissemination of these products in the avionics domain. Recent advancements in MEMS technology have made it possible to manufacture small, light, and low-cost Inertial Systems

Industry has not yet sufficiently advanced towards the development of a MEMS Silicon accelerometer which fulfills all requirements in terms of miniaturization, reliability, integrability and lifetime stability.

The Accelerometer design developed by the Topic Manager, has already demonstrated the potential to meet this target (50µg bias stability, 100µg bias repeatability over 25 years lifetime, see ref[73] below).

However, it is critical to be able to manufacture this design with a high reproducibility and good yields, to provide a low cost solution.

The maturity level of the accelerometer (TRL) is thus inseparable from the maturity of the MEMS manufacturing process (MRL).

In the context of this call, the applicant has to demonstrate the capability to produce prototype components in a production relevant environment (MRL5). The evaluation of those prototypes aims at demonstrating full accelerometer performances in relevant environment (TRL5).

A minimum TRL5 (performances maturity) and MRL5 (manufacturing maturity) level has to be reached at the end of this project in order to:

- Be able to implement the MEMS accelerometer in the Topic Manager Modular Inertial System demonstrator
- Be able to further industrialize the MEMS Accelerometer as a competitive product for a commercial launch by 2020.

Challenges will be:

- Identify and master a high accuracy etching technology on SOI silicon substrate for manufacturing of in-plane capacitive structure
- Develop a technology with minimum build-in stress from dissimilar material; Ideally a fully monocrystalline silicon solution is targeted (with a few silicon oxide layers admitted)
- Materials and technology shall be compatible with extended temperature range : -55/+105°C
- Technology shall include wafer level packaging functions for chip connections and assembly
- Proposed solutions for MEMS manufacturing and packaging shall be compatible with more than 30 years lifetime.
- As targeted applications are Inertial Systems requiring very high safety and reliability level, applicant shall be able to deliver process failure mode analysis as most process failure and drift will induce accelerometer failure. A full traceability monitoring system is also mandatory.

Some requirements are:

- Low capacitance TSV is required: < 3 pF
- Technology shall limit stress level on active sensing element: lower than 0.1 MPa measured through sensor outputs temperature coefficient deviation from silicon theoretical values.
- Assembly technologies and materials shall withstand high shock level up to 1000g
- Reliability must be demonstrated under up to 4000 thermal cycles (-40/+95°C)

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[73] Inertial Grade Silicon Vibrating Beam Accelerometer, O. LEFORT and al, Inertial Sensors and Systems – Symposium Gyro Technology 2012

2. Scope of work

The applicant shall perform the following activities:

Tasks		
Ref. No.	***Title – Description***	***Due Date***
WP1	Definition of the target MEMS manufacturing process (sensing element + package) based on a design to cost approach.	M3
WP2	Setup of the MEMS manufacturing process, assessment of critical parameters variability based on several manufacturing lots (at least 100 MEMS Accelerometers produced)	M10
WP3	Manufacturing of 20 MEMS Accelerometers (sensing element + package) and delivery to the Topic Manager for evaluation in relevant environment	M14
WP4	Optimisation of the MEMS manufacturing process based on WP3 results.	M20
WP5	Manufacturing of 40 MEMS Accelerometers (sensing element + package) and delivery to the Topic Manager for validation in relevant environment (TRL5)	M24

a) WP1: Definition of the target MEMS process

The Topic Manager already developed a MEMS Accelerometer design capable of Inertial Systems performances needs (<50µg bias stability over temperature). Based on the Topic Manager MEMS design, the objectives of this work package are to define a manufacturing process compatible with Cost, Performances and Reliability objectives.

The applicant shall demonstrate the coherence of its proposal through a detailed quantitative value analysis and design to cost approach covering the entire product (sensing element and its package).

The applicant will pay a special attention to the compatibility of the proposed solution with running industrial MEMS process and equipment such as to take profit of previous experience in industrialization of similar products and avoid any risk of duplication of effort or delays in results due inefficient fine tuning of manufacturing processes. The applicant will secure implementation of the MEMS manufacturing process within the planning of this project.

b) WP2: Setup of the industrial MEMS manufacturing process

The purpose of this work package is to implement a MEMS manufacturing process based on the analysis made in WP1 and to validate its capability to manufacture MEMS accelerometers according to the Topic Manager definition files.

Several batches will be manufactured (corresponding to the production of at least 100 MEMS

Accelerometers) in order to provide a quantitative analysis of the MEMS critical parameters variability.

c) **WP3: Manufacturing of 20 MEMS Accelerometers for evaluation by the Topic Manager**

The objective of this work package is to manufacture, test and deliver 20 MEMS Accelerometers (sensing element + package) for evaluation by the Topic Manager.
The evaluation by the Topic Manager will lead to a conformity matrix and a list of recommendations to reach the TRL level of 5.

d) **WP4: Optimisation of the MEMS manufacturing process**

The objective of this work package is to optimize the MEMS manufacturing process based on the results of WP2 and WP3.
The goal at the end of this WP is to demonstrate a MRL level of 5, while taking into account the requirements to reach the performances and reliability requirements.

e) **WP5: Sensors Evaluation : Manufacturing of 40 MEMS cells for evaluation by The Topic Manager**

The objective of this work package is to manufacture, test and deliver 40 MEMS Accelerometers (sensing element + package) for evaluation by the Topic Manager.
The evaluation by the Topic Manager will be performed with the goal to meet all the performances and reliability targets (TRL 5).

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D1.1	Design to Cost report	Report	M3
D2.1	Report on the implementation of the MEMS manufacturing process and assessment of critical parameters variability	Report	M10
D3.1	20 tested MEMS Accelerometers (sensing element + package) cells with CoC	Material	M12
D4.1	Report on the improvement of critical parameters variability	Report	M20
D5.1	40 tested MEMS Accelerometers (sensing element + package) cells with CoC	Material	M24
D5.2	Joint final summary (results, conclusions and recommendations) by applicant and THALES	Report	M24

Milestones (when appropriate)

Ref. No.	*Title – Description*	*Type*	*Due Date*
M1.1	Preliminary MEMS Cell design	Topic Manager input	M1
M3.1	Final MEMS Cell design	Topic Manager input	M12
M3.2	Recommendations on manufacturing process modifications to be performed to improve performances and reliability	Topic Manager input	M14
M5.1	Evaluation report update with Compliance Matrix	Topic Manager Input	M24

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

- Industrial experience in Silicon On Insulator (SOI) MEMS manufacturing.
- Industrial experience in manufacturing long term stable MEMS ceramic packaging under vacuum below 10^{-3}mbar (lifetime > 30 years).
- Industrial experience in zero-stress assembly process
- Capability to perform physical and functional tests of the device during front-end and back-end processes.
- Experience in high accuracy notch free Deep Reactive Ion Etching (DRIE) on thick SOI.
- Knowledge in the manufacturing and testing of high Q factor resonant MEMS Accelerometers.
- Ability to exploit the results of the project in a competitive and sustainable manufacturing process for long term production.

II. Solutions for voice interaction towards natural crew assistant

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP 1.2		
Indicative Funding Topic Value (in k€)	1100		
Topic Leader	Thales Avionics	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	21	**Indicative Start Date**[74]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-SYS-01-05	**Solutions for voice interaction towards natural crew assistant**
Short description	
The aim of the proposed activity is to develop and/or integrate the technologies required to implement an intelligent system such as the "natural crew assistant" in a cockpit environment, up to TRL3.	

[74] The start date corresponds to actual start date with all legal documents in place.

1. Background

A natural crew assistant is an intelligent system capable of listening to all communications occurring in the cockpit (either between crew members or between crew and ATC), recognizing and interpreting speech content, interacting with crew and fulfilling crew requests, such as to simplify crew tasks.

Intelligent personal assistants have been successful in the world of portable phones. They are based on natural language user interface to make recommendations, answer requests, and perform actions. The proposed activity aims at investigating whether this kind of assistant could be implemented in a cockpit environment. The activity will focus on the identification, selection and use of the technologies required to develop such assistant and on the adaptation of the proposed solution to the cockpit environment.

In general such an intelligent assistant makes use of the following technology components:

- Sound recording
- Voice recognition
- Sound Replay
- Voice synthesis
- An intelligent interpretation of the voice command according to the operational context.

In the context of Clean Sky 2, such an intelligent assistant is foreseen, in different possible operational concepts as a potential long-term option for the extended cockpit developed in ITD SYSTEMS/WP1. Initial high level requirements for each component are identified below.

Table 4: HIGH LEVEL REQUIREMENTS

Component	Requirement
Sound recording	Compatibility with and adaptability to headset microphone or ambient microphones. Robustness against noisy cockpit environment.
Voice recognition	High recognition rate (> 95 % for numeric values, keywords and pilot requests in natural language). Provision of a confidence index to all the recognized text, keywords or numeric values. Ability to recognize keywords and numeric values in the ATC communication from radio.
Artificial Intelligence	Interpretation of pilot requests expressed in a natural language (at the least English, not constrained by phraseology). Ability to suggest system actions well-suited to the operational context.

2. Scope of work

The applicants shall perform the following activities:

Tasks		
Ref. No.	***Title – Description***	***Period***
WP1	Audio evaluation environment.	M0-M6
WP2	Designing/evaluating solutions for basic cockpit Sound Recording/Voice recognition systems	M2-M12
WP3	Designing/evaluating solutions for the natural crew assistants	M5-M21

a) <u>WP1 : Audio evaluation environment</u>

The objective of this work package is to develop an audio evaluation environment. The audio evaluation bench should be representative of the audio environment of a cockpit in all flight phases (At gate, Taxi, climb, take-off, cruise, descent, landing). It should allow evaluating the sound recording/Voice recognition systems and the natural crew assistants according to evaluation scenarios provided by Topic manager. These evaluation scenarios include crew communication and ATC communications hence the audio evaluation bench should be able to test both kind of communications. The audio evaluation environment shall include the capability to immerge the speaker in the representative cockpit noise context (from noise recorded in different flight phases, provided or procured by the applicant).
A detailed description of the expected capabilities of the audio evaluation environment and the requirements for its integration in the cockpit demonstrator will be jointly developed and agreed upon by the Topic Manager and the partner. The topic manager will provide the description of a cockpit demonstrator which is representative of the targeted cockpit. The applicant is expected to integrate the audio evaluation environment into the Topic Manager cockpit demonstrator.

b) <u>WP2: Designing/evaluating solutions for basic cockpit sound recording/voice recognition system</u>

The purpose of this work package is to develop and evaluate several solutions for a sound recording/voice recognition system to be integrated in the evaluation bench developed in WP1.
The aim is to evaluate the compliance of recording/voice recognition system to the high level requirements defined in Table 1 in different flight phases (at gate, taxi, climb, take-off, cruise, descent, landing).
The evaluation scenarios provided by the topic manager will describe several operational contexts and the corresponding expected behaviours of the sound recording/voice recognition system in these operational contexts.
Considering the complexity of the targeted functions and the effort required for the implementation, an iterative approach is suggested, with short designing/evaluation cycles to verify the fulfilment of the high level requirements in the various evaluation scenarios.

c) <u>WP3: Designing/evaluating solutions for natural crew assistant</u>

The purpose of this work package is to develop and evaluate several solutions for the implementation of

a natural crew assistant to be integrated in the evaluation bench.
The developed module will be the interface between the voice recognition sub-system developed in WP2 and the A/C systems on one hand (for the commands) and with the pilot on the other hand (interactive dialogue).

This crew assistant shall provide an autonomous interpretation of pilot requests expressed in a natural language (at the least English). As an output the crew assistant will suggest system actions well-suited to the operational context. The underlying algorithms shall be selected, implemented and tested by the applicant.
The aim is to evaluate the compliance of the proposed crew assistant solution with the high level requirements defined in Table 1 in different flight phases (At gate, Taxi, climb, take-off, cruise, descent, landing).
The evaluation scenarios provided by the topic manager will describe several operational contexts and the expected behaviours of the natural crew assistant in these operational contexts.
This WP also includes the support to the Topic Manager for integration into the evaluation bench and for the assessment of the delivered solutions.
Here again, an iterative approach is suggested, with short designing/evaluation cycles to verify the fulfilment of the high level requirements in the various evaluation scenarios.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D1.1	audio evaluation environment	HW/SW	M6
D2.1	Report on the initial Design of the sound recording/voice recognition system	Report	M5
D3.1	Evaluation report of the sound recording/voice recognition system	Report	M12
D3.2	Report on the Design of the natural crew assistants	Report	M14
D4.1	Evaluation Report on the improvement of critical parameters variability	Report	M20

Input from TM			
Ref. No.	***Title – Description***	***Type***	***Due Date***
I1.1	Detailed description of the expected capability of the audio evaluation bench	Topic Manager input	M1
I2.1	Description of evaluation scenarios for the sound recording/voice recognition system evaluation.	Topic Manager input	M3
I3.1	Description of evaluation scenarios for natural crew assistant system evaluation.	Topic Manager input	M12

Input from TM			
I2.2	Template and guideline for sound recording/voice recognition system evaluation.	Topic Manager input	M6
I3.2	Template and guideline for natural crew system evaluation.	Topic Manager input	M15

Milestones			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M1	audio evaluation environment integration review	Review	M7
M2	Final validation and acceptance	Review	M20

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

- proven experience on sound recording/voice recognition or intelligent assistant.

III. Affordable Electro-Optical Sensor Cluster/Assembly Unit (LRU) for Vision & Awareness enabling Enhanced Vision, Sense & Avoid, and Obstacle Detection Systems for Aeroplane and Helicopter All-weather Operations and enhanced safety

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP 1.3.5		
Indicative Funding Topic Value (in k€)	1500		
Topic Leader	SAAB	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[75]	Q1 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CfP06-SYS-01-06	**Affordable Electro-Optical Sensor Cluster/Assembly Unit(LRU) for Vision & Awareness enabling Enhanced Vision, Sense & Avoid, and Obstacle Detection Systems for Aeroplane and Helicopter All-weather Operations and enhanced safety**
Short description	
Development - up to TRL5 - of an Affordable Multi-channel Sensor cluster assembly (LRU) with image algorithms providing a video stream covering visual to long-wave IR bands and based on non-export restricted technology.	

[75] The start date corresponds to actual start date with all legal documents in place.

1. Background

Previous generation Enhanced Flight Vision (EVS) systems use Cooled SW-IR sensors to detect (primarily) filament lamp runway approach light systems, thereby satisfying certification requirements to enable continued visual final approach. These sensors are prohibitively expensive for a wide market application, and their performance limited. Latest development use un-cooled multi-spectral sensors, that solves some of the issues but that still are limited in weather performace and by cost. The unit developed under this call should enable a further step by combining affordable IR sensors that will be combined by the integrator with a mmW-radar to provide the final step in satisfying the new certification requiremerents beeing developed for future EFVS-systems, thereby increasing regularity, enhancing safety and enabling the next generation Air Traffic Control systems defined by SESAR (EU) and Nextgen (USA)

The sensor assembly developped under the proposed activity will stream video to a Vision & Awareness system, where the images from the Multi-spectral Sensor Unit will be combined with data from other sensors such as mmW-Radars and databases to provide a complete enhanced and synthesized images suite to enble the aircraft functions;

- Enhanced Vision System (video presented on a HUD)
- Obstacle Awareness System (detecting ground obstacles)
- Sense and Avoid systems (detecting other moving objects, e.g. UAV's)
- Image based navigation (Final approach phase)

The system will be used in all phases of flight, from Taxi, Take-off, cruise and landing phases, both for aeroplanes and helicopters e.g. to enable Helicopter Civilan Police, Ambulance and Rescue operations, in all weathers and at all sites of operation.The unit(s) will be used for Ground and Flight Evaluation

Detailed specifications for the sensor assembly will be defined within the activity, using input from the topic manager. A possible preliminary set of requirements is thereby provided, as a reference to allow applicant better understanding the technology challenges in the proposed work.

Preliminary Minimum Requirements Overview	

Performance	• Sensor: Affordable (uncooled) sensors
	• Spectral range: Visual, NIR and LWIR
	  ○ SWIR optional
	• Field-Of-View: Horizontal 45^o ; Vertical 30^o
	  ○ Zoom; optional electrically controllable
	• Resolution: 640 x 480 pixels (IR-bands)
	  ○ Visual & NIR, as high as affordable
	• Frame rate: ≥30 Hz
	• Latency: <30 ms

Physical	• Weight: <2 kg • Standard digital interface: Ethernet or ARINC818 • Added analogue interface (option) • Control interface: RS-422 (or RS-232) • Connectors: Aviation standard

Preliminary Minimum Requirements Overview	
Reliability	• MTBF: 40 000 hour • Non Uniformity Correction: Automatic/Manual
Maintainability and testability	• ITAR free • Internal tests (BIT)
Environmental conditions	• Comply with RTCA DO-160G • Temperature: -55 to +70 ^{o}C • Power: 28 V (22.0 - 30.3 Volt)

Table 5: Perliminary Requirements Overview

The objectives of the proposed work are:

- Provide a cost effective and ITAR free Unit. Use Affordable (uncooled) IR sensors (Visual, NIR to LWIR) for System integration and flight evaluation.
- To define an optical solution for the sensors.
- Develop an efficient mechanical and electrical build for the required functions.
- Define and implements algorihms for providing the image data stream.
- Test, validate and qualify the Unit in relevant environment.
- Provide units for Aircraft System integration, evaluation and demonstration.

The Topic Manager will provide support towards certifiability. However, the use of a development process that will allow/enable a system integrator to certify the LRU as part of a Enhanced Vision System is encouraged.

2. Scope of work

The propopsed activity is planned within the SYS ITD Work Program as part of the WP1.3.5 – EVO and awareness.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T01	Definition phase with final specifications ()	T0 +2
T02	Design Phase Review with respect to certifiability, Electro-Optical, Electronic, Mechanic and Algorithms and/or SW/VHDL providing data stream (Joint)	T0+10
T03	Production of evaluation EOS LRU units	T0 + 14
T04	Integration and run-up	TO + 15
T05	Environmental and Functional Testing	T0+17
T06	Integration and Evaluation of the unit / validation and flights	T0+18 to 24

The Unit HW should be developed and tested to prove TRL5 on unit level (i.e tested in relevant environment). SW and Algorithms may be lower TRL but should provide full functionallity.

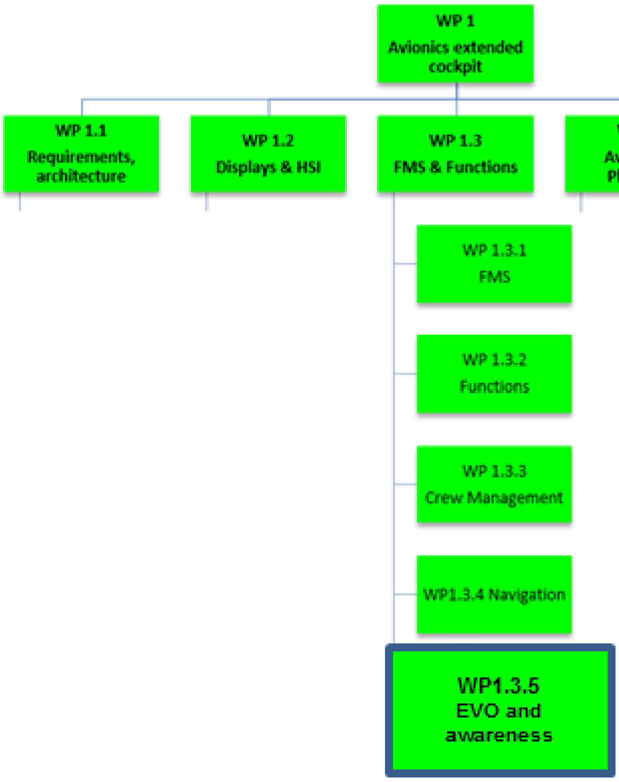


Figure 18: WP 1.3.5 EVO and Awareness in Clean Sky 2 Systems ITD WP1

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D0	Final EOS LRU Specification	R	T0+2
D1	HW Design Data package enabling certifiability review_	HW	T0+10
D2	Algorithm Definition or SW/VHDL equivalent providing the image data stream, enabling certifiability review.	R, D	T0+14
D3	One SRU or LRU combining all necessary HW (may or may not contain functionally required SW or VHDL enabling, if developed by different parties)	R, D	T0+14
D4	Operational LRU to TRL6(HW) sending video on selected interface, with test reports	HW, R	T0+15
D5	System integration, verification and test results report	R, HW	T0 + 18

*Types: R=Report, D-, HW=Hardware

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	System Specification on EOS LRU - acceptance	R	T0+2 months
M2	Design Review with Respect to the design chosen, including certifiability aspects	D	T0+9
M3	Delivery and acceptance of the sensor assembly (2 units)		T0+18

*Types: R=Report, D-Data, HW=Hardware

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

- Applications are encouraged also from non-aviation sector,
- Design, Production and Environmental and Functional Test capability for Electro Optical Assemblies from Visual to Long-range IR, capability to guarantee configuration control.
- Image enhancement and optimization algorithm capability for the used sensors and technologies.
- Capacity to define the algorithms and provide or source the neeed SW/VHDL, if needed.

5. Abbreviations

EOS	Electro-Optic Sensor(s)
EVO	Equivalent Visual Operations
Visual	Visual spectral band, 0.4-0.9um
SWIR	Short-wave spectral band, 0.9-1.7 (2.5) um
LWIR	Long-wave spectral band, 7-14 um
LRU	Line replaceable Unit (A complete assembly, may or may not contain a data load)
HUD	Head up Display
mmW	Millimetre Wave (radar)
NIR	Near IR band
CoC	Certificate of Conformance
SW	Software
VHDL	Very High Definition Language

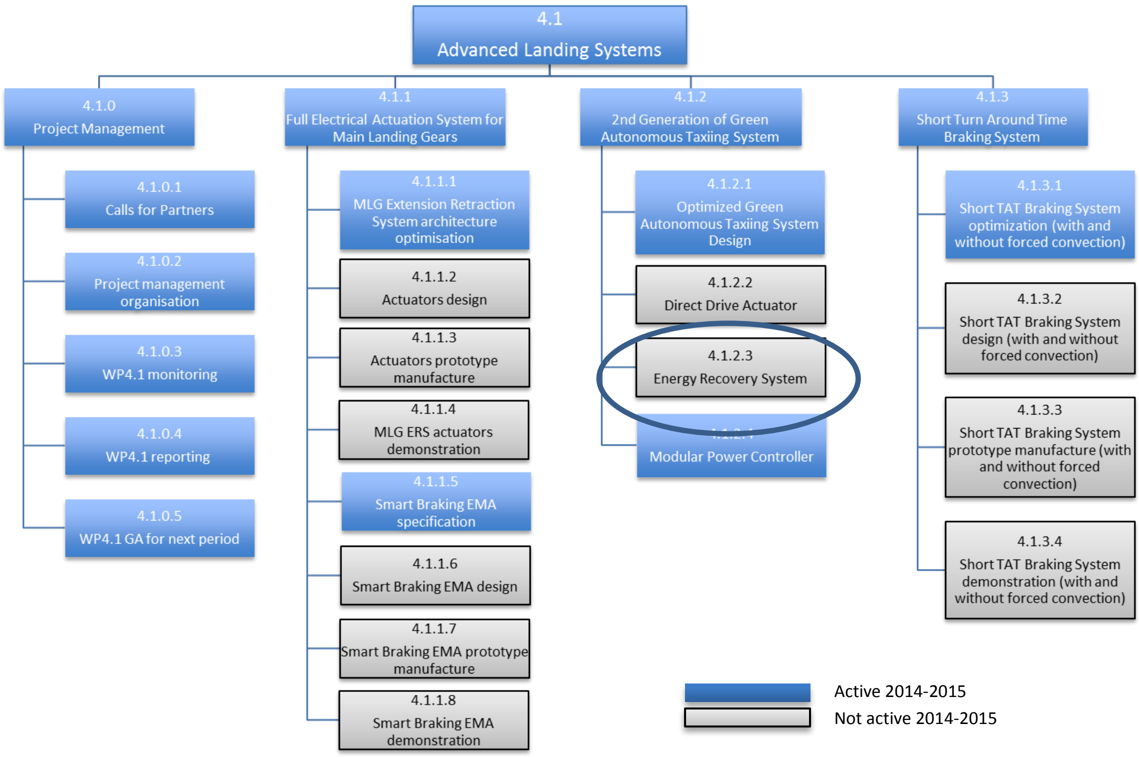
IV. High density energy storage module for an electric taxi

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP 4 – Landing Gear Systems		
Estimated Topic Value (funding in k€)	800		
Topic Leader	Safran	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	45	**Indicative Start Date**[76]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-SYS-02-29	**High density energy storage module for an electric taxi**
Short description	
This project will develop an energy recovery module connected to an electric green taxi system. This equipment shall provide an high density energy recovery capability (30Wh/kg), with associated power converter, in order to perform aircraft electrical decelerations.	

[76] The start date corresponds to actual start date with all legal documents in place.

1. Background



Studies for the electric taxi system have shown that it will provide significant fuel savings (and emissions reductions) for single aisle aircraft. The studies have also indicated fuel and emissions reduction opportunities in other aircraft types ranging from helicopters, business jets and regional jets, up to a short-haul wide body aircraft.

The current demonstration systems, used for proof of concept, can be significantly improved in many respects, including the following:

- Weight and size: Weight reduction of the electric taxi system has direct impact on aircraft fuel burn; the power density of the power module is an important driver with the potential for dramatic improvement.
- Landing gear integration: Integration of the wheel actuators into the landing gear is challenging due to the severe environment constraints. There is an opportunity to develop a robust, integrated system that can be used across multiple applications. To achieve optimal integration of the overall system, both the wheel actuator and the power module must be developed in close collaboration.
- Cost reduction: Considering the range of the target platforms, an efficient approach to modularity must be taken. The system and its elements should be carefully designed to fulfill the varying range of requirements while maximizing re-use of equipment (at least parts of it) instead of redesign everything during each development phase.
- Increased efficiency: The overall aircraft system energy efficiency needs to be maximized. This can be achieved by employing advanced energy management to ensure that energy is not wasted, and power

sources are not oversized. Regenerated energy produced by braking during taxi shall be absorbed by the system to perform useful work, rather than being dissipated in resistors as is the case in the first generation of the system. This capability requires the power module to manage bi-directional energy flow, including conditioning the regenerated power into a usable form with acceptable power quality.

This project shall develop the next generation power module which will be part of a scalable and modular electric taxi system. It will interface with the system module, aircraft electric power system, and the electric taxi system wheel actuators. Its functions are to provide controlled power to the wheel actuator electric motor, and to condition/return regenerated power to energy storage or the aircraft power system. Specific and detailed requirements will be defined during the initial studies, to support an overall, optimized electric taxi system design.

These studies, led by the electric taxi system integrator, will consider: using direct drive vs. geared actuators; different motor topologies; smart actuators (where the power/control electronics are co-located with the actuator); and approaches to regenerated energy management/use. The power module architecture will have to address all these requirements. The power system architecture and the power module must developed taking into account aircraft integration constraints such as volume, temperature/cooling, vibration, noise, EMI/EMC, cost, etc. to achieve a demonstration close to TRL6.

The proposed activity is aligned with the following Systems ITD Strategic Objectives:

- CO_2 and fuel burn: The fuel burn (and related CO_2 emisions) reduced by 61% during the taxi phase. Depending on the mission type, up to 4% reduction of overall specific fuel consumption.
- NO_x emisions: The NO_x emissions reduced by 51% during the taxi phase. Depending on the mission type, up to 3% reduction of the overall NO_x emissions.
- Population exposed to noise / Noise footprint impact: Reduction of the ground noise level during taxiing by approximately 10 dB during the taxi phase.

While the existing demonstration systems are targetting specific aircraft, the development of the modular and scalable system allows deployment on various aircraft types. This development is therefore a necessary enabler for an industry-wide electric taxi system introduction.

2. Scope of work

The proposed activity will develop the high energy density power module for the next generation electric taxi system.

A significant power density increase (reduced size and weight), compared to current state-of-the-art, shall be achieved. The power module shall feature bidirectional power conversion capability to manage and store the energy regenerated by electric taxi motors during aircraft deceleration. It shall be modular and easily scalable to support a wide range of platform requirements with maximized re-use. The power module shall have the capability to perform electrical deceleration, should it be necessary for some aircraft applications. The power module shall be designed for optimal integration with the electric taxi system traction motor and wheel actuator control unit, as well as with the electric taxi system module. The scope of the activity includes integration of the communication interfaces and mechanical integration in a aircraft or landing gear, which will take placeat the site of the TM.

The technology focus of the proposed activity is on:

- Innovative energy storage packaging, adapted balancing & cooling.
- Advanced module topologies and filtering technologies
- Optimized control algorithms and balance monitoring system
- Additional functions as agreed between the applicant and the topic manager

The specific requirements for the power module include:
- Bi-directional operation for storage and recycling energy
- Energy storage capability – The energy storage capability module shall be able to store up to 700Wh (2500kJ)
- Power: The power module shall be able to manage up to 50kW power regenerated from wheel actuator
- Bus voltage – The power module shall operate from the +/-270V DC bus
- Environmental conditions – The power module shall meet the DO-160 standard
- Electrical standards: The power module shall meet DO-160 standard

Quantified objectives:
- Weight
    - target mass for storage technology is at least 30Wh/kg
    - target mass for power electronics is at least 2kW/kg
    - target mass for the whole unit is 40kg.
- Volume – target volume power density is 2kW/l

An Implementation Agreement will be drafted, agreed upon and signed by the applicant, the topic manager, and its partners, which will define the intellectual property rules and the means for the exploitation of results.

Tasks		
Ref. No.	***Title – Description***	***Due Date*** [T0+mm]
T4.1.2.4.01	Support analysis of the overall system requirements and definition of power module detailed requirements (provide inputs for system optimization: optimum design between Power Electronic, Storage device and wheel actuator Characteristics)	T0+3
T4.1.2.4.02	Support analyses and trade-off studies of storage technologies (provide input for aircraft integration & installation system activities)	T0+9
T4.1.2.4.03	Analysis and trade-off studies of buck/boost converter topologies, and filtering approach	T0+9

T4.1.2.4.04	Analysis and trade-offs of mechanical integration approaches, including packaging and cooling	T0+9
T4.1.2.4.05	Support identification and analysis of potential additional functional requirements such as balance monitoring system	T0+9
T4.1.2.4.06	Definition of interface requirements and integration procedures	T0+9
T4.1.2.4.07	Power module architecture definition	T0+9
T4.1.2.4.08	Power module safety and reliability analysis	T0+9
T4.1.2.4.09	Development of the Power module to TRL4	T0+21
T4.1.2.4.10	Laboratory evaluation of the Power module critical functions	T0+21
T4.1.2.4.11	Power Module integration simulation model development	T0+26
T4.1.2.4.12	Development of the Power Module to TRL6	T0+33
T4.1.2.4.13	Laboratory testing and evaluation of the Power Module	T0+33
T4.1.2.4.14	EMI/EMC testing	T0+39
T4.1.2.4.15	Laboratory demonstrator integration	T0+45
T4.1.2.4.16	Laboratory testing	T0+45

The initial stage of the activity will analyze the high-level requirements and prepare detailed requirements for the Power Module. This will be followed by technology trade-off studies to analyze and define:

- The best topology for power module (energy storage technology and power electronics conversion)
- The best approach to Power Module cooling and packaging, accounting for different target platforms, and scalability

This will be followed by the interface definitions and an overall integration procedure preparation together with the activity lead.

The next stage will define the Power Module architecture, followed by the preliminary safety and reliability analysis. In the following stage, the applicant will develop the power module up to TRL4 and perform laboratory validation tests for any critical functions. A power module simulation will feed an overall integrated system simulation performed by the topic manager. The development of the Power Module will then continue up to reaching TRL6. This will include additional laboratory performance tests, and EMC/EMI testing. The TRL6 prototype will then be integrated with the rest of the next generation electric taxi system which will be tested, validated, and demonstrated in collaboration with the topic manager.

The proposed activity shall therefore develop the next generation Power Module up to TRL6 validated by system tests. IIt is expected that the applicant will build on existing designs and knowledge, and optimize the effort on the technology challenges (for example, power density, minimized cooling, etc., where the development may start from a lower TRLs.

3. Major deliverables and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D4.1.2.4.1	Power Module system requirements analysis and detailed requirements definition	Report	Q4 2017
D4.1.2.4.2	Power Module TRL4 critical function laboratory test report	Report	Q4 2018
D4.1.2.4.3	Power Module simulation model	Model	Q2 2018
D4.1.2.4.4	Power Module TRL6 laboratory test report	Report	Q4 2019
D4.1.2.4.5	TRL6: Power Module integrated with system ground demonstrator	Hardware	Q3 2020
D4.1.2.4.6	Laboratory demonstrator test report	Report	Q4 2020

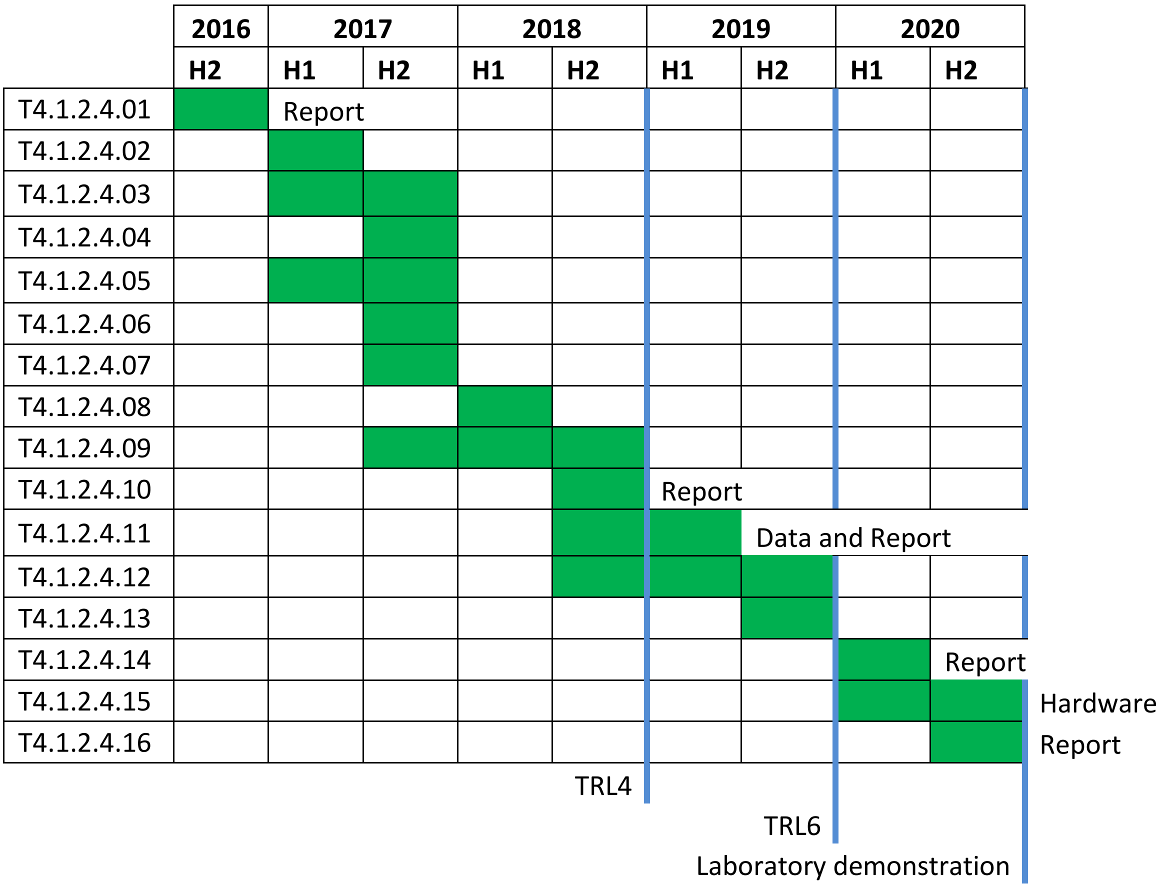


Table 6 – Project estimated schedule

4. Special skills, Capabilities, Certification expected from the Applicant

- Relevant expertise in energy storage systems development
- Relevant expertise in aircraft power electronics development
- Relevant experience in aircraft system integration and installation, possibly with experience as aircraft electronic system supplier
-
- Experience in collaborative research
- Relevant experience in multi-disciplinary integration in aerospace (fosuc on electrical, mechanical, thermal and avionics systems)
- Knowledge of aerospace development, quality standards and certification processes
- Proven capability to deliver timely; capacity to manage resources in line with the principia of economy, efficiency and effectiveness
- The applicant must ensure resources are available for main taks in-house and should avoid subcontracting for the research, development, simulation, and testing
- The applicant must be able to establish and procure an industrialization plan for the TRL6 final review for all the necessary components and materials

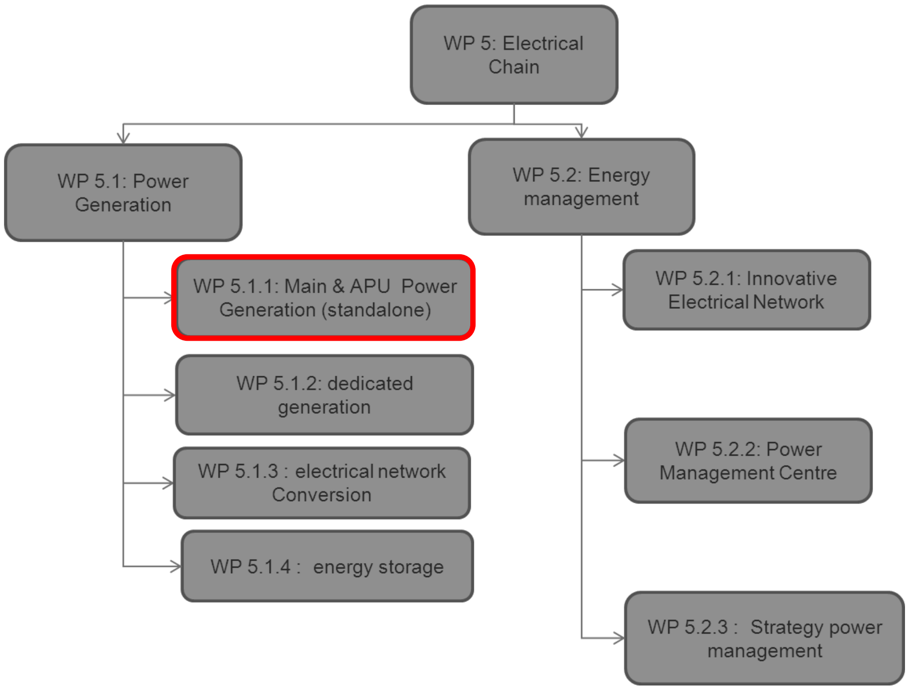
V. Innovative pump architecture for cooling electrical machine

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP 5 – [WP 5.1.1]		
Indicative Funding Topic Value (in k€)	800		
Topic Leader	Thales Avionics	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	30	**Indicative Start Date**[77]	Q1 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CfP06-SYS-02-30	**Innovative pump architecture for cooling electrical machine**
Short description	
Due to the continuous increase of electric power needs aboard aircrafts, aeronautic industry is looking for new pump designs to improve performance of high power machines oil cooling systems while optimizing mass, durability, and availability as required by aircraft manufacturers. The proposed work aims at designing and developing a high performing oil cooling systems for high power machines.	

1. Background

[77] The start date corresponds to actual start date with all legal documents in place.



The major objective of "Main and APU Power Generation" project is to actively prepare the ATA24 System for the future generation of aircraft power network and to develop the next generation of power starter generator. Through these studies, process and technologies will be evaluated and challenged to usual solutions.

2. Scope of work

Due to continuous increase of electric power needs aboard aircrafts, electric generation system and more specifically VFSG (variable frequency starter generator) are required to deliver more and more power. This however causes power loss through diverse heating phenomena (copper losses, Eddy current losses, mechanical frictions…) to increase as well. For this reason aircraft power generation applications need new oil cooling systems serving such high power machines and allowing to optimize mass, durability, and availability as required by aircraft manufacturers.

With regards to new high power VFSG developments, innovative pump designs are envisaged to allow:

- Enhanced pump integration and scale reduction for easier installation inside the machine, lower impact on overall machine envelope, and on design complexity
- Reduction of maximum number of moving parts for higher durability and availability
- Optimization of pump efficiency

For instance, These goals may be reached using housingless pump that can be installed directly installed inside the oil tank, or pump rotating at higher speed that do not use reduction systems to adapt to the machine speed. The domain of possible design is very large and the TM expects that the applicant performs an exhaustive study covering:

- state of the art analysis
- pump innovative design architectures score card (innovation expected in terms of compactness and operating speed
- preferred design selection, specification and definition
- prototype manufacturing and testing of the selected solution

Required performances

- 23l/min minimum flow
- above 10 bars output pressure
- operational speed range (ratio between max. operating speed and min. operating speed): x2,1 - typical VFSG min. operating speed : 8000 rpm for 6-pole machines, or 12000 rpm for 4 pole machines. Direct shaft coupling shall be preferred. In case of use of a reducer between VFSG shaft and pump, the reducer ratio shall be minimized.
- over speed capability : 5 minutes at min +20% above max operating speed

Environmental conditions

Operating temperature: -40°C to +180°C

Vibration level: DO160 category U&W with amplification factor of 500% from 150 to 300Hz.

Hydraulic fluid used: turbine oil MIL-PRF-7808 and MIL-PRF-23699

Interfaces

The pump is located inside an electrical generator

The mechanical power is provided by the generator shaft

TRL5 is expected at the end of the project.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 1	**Specification freeze** With the support of the topic manager the partner(s) shall define the specifications	T0 + 1 Month
Task 2	**State of the art** The partners shall provide a choice matrix justifying the technology choice according to the specification criteria provided in task 1 and with reference to a detailed state of the art analysis.	T0 + 4 Months

Task 3	**Preliminary design** The applicant shall provide a preliminary design analysis including functional justification, mechanical and fluid calculation. All the justification shall be based on a DFMEA. Applicant is requested to develop one or more mock-up able to demonstrate the compliance of the technology selected (one mock-up is to be provided to the topic manager).	T0 + 8 Months
Task 4	**Design** The applicant shall provide the final design with a reasoned trade-off study result (and DFMEA)	T0 + 20 Months
Task 5	**Prototypes manufacturing** The applicant is requested to manufacture the prototypes (2 will be delivered to the topic manager for testing purposes)	T0 +24 Months
Task 6	**Qualification tests** The applicant is requested to carry-out qualification tests on the prototypes such as: - Performance (temperature and altitude) - Vibration - Endurance (vibration, pressure cycling, pollution, temperature cycling, altitude….) - Robustness (Vibration and temperature) The applicant shall provide test reports.	T0 +30 Months

Note: the quantity of mock-up and prototypes are referred only to the Topic manager needs. The applicant shall define the quantity of mock-up and prototypes required for the validations in task 3 and 6.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	State of the Art study results	document	T0 + 1 Month
D2	Technology choice matrix	component	T0 + 4 Months
D3	Preliminary design	document	T0 + 8 Months
D4	Development test plan	document	T0 + 9 Months
D5	2 pump demonstrators	hardware	T0 + 12 Months
D6	Development test report	document	T0 + 16 Months
D7	Design detailed report	document	T0 + 20 Months
D8	Qualification test plan	document	T0 + 22 Months
D9	2 pump prototypes	hardware	T0+24 months
D10	Final qualification test report	document	T0+30 months

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
KOM	Kick Off meeting		T0
PDR	Predesign review : pump architecture and technology selection		T0+8 months
CDR	Design review : pump definition and Test bench design freeze reproducing environmental conditions (mechanical constraints and temperature variation, dedicated or combined conditions)		T0+20 months
TRR	Test readiness review: test specification freeze.		T0+24 months
QR	Qualification review : Tests results and reports		T0+30 months

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

- Strong knowledge of oil cooling system and pump technology and architecture
- Strong knowledge and extensive experience on mechanical calculation and thermal calculation
- Strong knowledge in product development and design tools (Development plan, product and process FMEA)
- Facilities to conduct fatigue and combined robustness tests.

Experiences in R&T and R&D programs, possibly in the aerospace domain and related research programs.

In-house testing capability will have to be emphasized in order to propose an integrated design, manufacturing and testing approach.

Availability of test benches or capacity to design and manufacture test benches to support test campaigns is essential.

VI. Power Module

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP 5 – [WP 5.1.3]		
Indicative Funding Topic Value (in k€)	500		
Topic Leader	Thales Avionics	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	18	**Indicative Start Date**[78]	Q1 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CfP06-SYS-02-31	**Power Module**
Short description	
The scope of this call is to design a packaging for electrical power component. Solution with discrete power component avoids reaching high power density for the next generation of conversion products. Technical challenges are expected in assembly of the different layers of power component to meet harsh environment and high current applications.	

[78] The start date corresponds to actual start date with all legal documents in place.

1. Background

The more electrical aircraft or the all eletrical aircraft design targets demand more electrical power to be available on board of future aircraft. However weight savings are also necessary to reach technical targets. Integrated power electronic module shall contribute to weight reduction as it will enable to replace discrete power components and electro mechanical contact, achieve greater degree of integration and consequently increase the power density of electronic products.

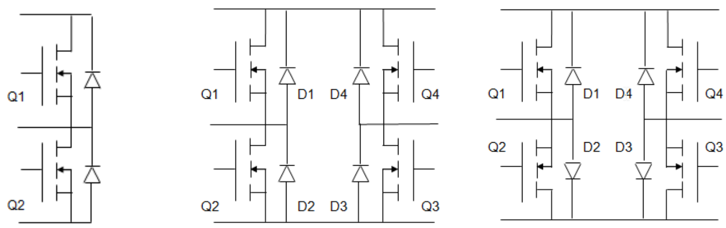
2. Scope of work

The proposed activity aims at developing three types of power semiconductor devices with an expected maturity level up to TRL6. The packaging of the power semiconductor device shall be adaptable to allow easy deployment of three different applications with the same base plate and packaging. The size of the power component dies soldered in the packaging module shall be well-matched to the three applications.

The applicant shall provide also the monitoring and ON-OFF functions (or driver) to validate the power modules to simplify the development of the functions, PCB (Printed circuit Board) solution with discret components might be envisaged. For the functions, a minimum TRL4 is required at demonstrator phase.

The three targeted applications are :

- HVDC (High Voltage Direct Current) fullbridge module consisting of power semiconductors with freewheeling diode on each power semiconductor. The power module shall be validated with an active HVDC converter providing an output power up to 5kW.
- LVDC (Low Voltage Direct Current) halfbridge module consisting of top and bottom power semiconductors with freewheeling diode on each power semiconductor. The power module shall be validated with an active HVDC converter providing an output power up to 5kW.
- HVDC bidirectional controlled power module. The expected application is a contact matrix where no power cutting is required. A number of power modules shall be procvided such as to allow implementing a contact matrix with four source (HVDC three phases, each source supplies up to 50kVA) and 5 loads (HVDC three phases with a consumption up to 50kVA). The commutation of each power modules shall be controlled through a CAN Bus.



Application schematics

(halfbridge on the left side, full bridge in the center and bidirectional module on the right side)

For the contact matrix application case, the applicant shall have the capability to develop the test benchs to validate the semiconductor module and its reliabilty in the dedicated application. Some modules shall be provided to the topic manager for further tests.

Main characteristics for the semiconductor module :

- Electrical characterisitcs :
  - SiC MOS: 1200V / 60A (Or similar die component)
  - Si MOS: 150V / 400A (Or similar die component)
  - SiC Diode: 1200V / 50A (Or similar die component)
  - Insulated base plate: the mounting surface must be isolated from any terminals.
- Mission profile:
  - In line with 200.000 flight hours, specified as follow with environmental conditions

Phases	Conditions	Mission	Hours / cycle	
Power-on (flight hours)	-40°C	10% of flight hours	20.000 h	
	40°C	80% of flight hours	160.000 h	200.000 FH
	85°C	10% of flight hours	20.000 h	
	$\Delta\Theta$ = 50°C	Thermal cycle	3000 h	
Power off (dormant hours)	16°C 77%RH	35% of fligh	70.000 h	
	Thermal cycles -55°C to 85°C	Thermal shock 20s maximum transfer time	500 cycles	

- ROHS and REACH directives :
  - Both unleaded and leaded reflow soldering process shall be compatible with the ROHS and REACH directives
- Thermal perfomances :
  - Power module : Junction temperature up to 175°C
  - PCB for dedicated functions : temperature -55°C up to 85°C
  - Asimulation study of the proposed design shall provide a prediction of the heat transfer between the different layers and the identification of hot spots.
  - Thermal characterisitcs shall be provided (Junction to case thermal resistance, and transient junction to case thermal impedance from 10µs to 10s)
- Mechanical robustness :
  - Compliance with DO160 standard

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 1	**Specifications** Based on the input provided by the TM, the partner(s) shall define the specification of the power module and the applications. • Trade off study on state of the art power module packaging compliant with harsh environment conditions, costs, and dedicated applications. • Trade off study on the choice of the semiconductors dies (power SiC MOSFET or/and GAN is required for the power switch,),	T0 + 1 Month
Task 2	**Preliminary design** The applicant shall provide a preliminary design analysis - including functional mechanical and thermal aspects - suitable for the targeted applications. The applicant is requested to provide a mock-up of the packaging and to demonstrate the packaging technologies.	T0 + 3 Months
Task 3	**Design** The applicant shall provide the final design of the power module. Tests plan for the demonstrator shall be provided.	T0 + 7 Months
Task 4	**Prototypes manufacturing** The Applicant will manufacture the power module according the specifications. The number of prototypes manufactured shall be such as to allow validating the power module and manufacturing the demonstrators for the targeted applications. In addition, the applicant will provide a number of samples (3 x 40 power modules) to the topic manager.	T0 + 13 Months
Task 5	**Qualification tests for the power module alone** The applicant shall carry-out qualification tests on the power module such as: - Performance (temperature) - Vibration - Endurance (vibration, pressure cycling, pollution, temperature cycling, altitude….) - Robustness (Vibration and temperature) Applicant shall provide detailed test reports.	T0 +18 Months

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 6	**HVDC active converter demonstrator design review** The applicant shall provide the design data for the demonstrator using the power module in the active converter configuration. Monitoring, protection and driver functions dedicated to this application shall be provided. Tests plan for the demonstrator shall be provided	T0 + 8 Months
Task 7	**HVDC active converter demonstrator manufacturing** The applicant will provide a demonstrator (at least TRL4) fulfilling the functional conditions	T0 + 14 Months
Task 8	**HVDC active converter validation.** Functional conditions and electrical performances shall be tested. Tests report and one operational demonstrator shall be provided to the topic manager.	T0 + 16 Months
Task 9	**HVDC matrix contact demonstrator design review** The applicant shall provide the design data for the demonstrator using the power modules in the contact matrix configuration. Monitoring, protection and driver functions dedicated to this application shall be provided. Test plan for the demonstrator shall be provided.	T0 + 8 Months
Task 10	**HVDC contract matrix demonstrator manufacturing** The applicant will provide a demonstrator (at least TRL4) fulfilling the functional conditions	T0 + 15 Months
Task 11	**HVDC contract matrix Functional validation** Functional conditions and electrical performances shall be tested. Tests report and one operational demonstrator shall be provided to the topic manager.	T0 + 18 Months

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Specifications and report on reasoned trade-off study results	document	T0 + 1 Month
D2	Preliminary design report and preliminary qualification test plan	document	T0 + 3 Months
D4	Design report and final qualification test plan.	document	T0 + 7 Months
D5	Power modules prototypes (40 modules for the topic manager and additional modules for qualification campaigns and the demonstrators)	hardware	T0 + 13 Months

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D6	Final qualification test report	document	T0 + 18 Months
D7	HVDC active converter demonstrator design report with functional test plan	document	T0 + 8 Months
D8	HVDC active converter validation report	document	T0 + 14 Months
D9	One operational HVDC active converter demonstrator	hardware	T0+ 16 Months
D10	HVDC contact matrix demonstrator design report with functional test plan	document	T0 + 8 Months
D11	HVDC contact matrix validation report	Document	T0 + 15 Months
D12	One operational HVDC contact matrix demonstrator	hardware	T0+ 18 Months

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
KOM	Kick Off meeting		T0
PDR	Predesign review		T0+3 months
CDR	Design review : power module definition and Test bench design reproducing environmental conditions (mechanical constraints and temperature variation, dedicated or combined conditions)		T0+7 months
TRR	Test readiness review: power module final test plan.		T0+13 months
QR	Qualification review : Tests results and reports for power module and demonstrators		T0+18 months

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

Capability to manufacture or to procure semiconductor die

- Knowledge on design, product and assembly of power module (assembly die in insulated packaging) compliant to harsh environments.
- Knowledge of characterization electrical Tests, fatigue and combined robustness tests.
- Capability to develop demonstrators and to evaluate power module in the targeted applications.
- Capability to design electronics board and to realize monitoring and ON/OFF by CAN bus (for contact matrix application).
- Facilities for fatigue and combined robustness tests.
- Experiences in R&T and R&D programs, possibly aerospace related research programs.

- Availability of test benches or capability to design and manufacture test benches in support of validation test campaigns is essential.

VII. Development of functionalizable materials

Type of action (RIA or IA)	IA		
Programme Area [SPD]	SYS		
(CS2 JTP 2015) WP Ref.	WP 5.2.1		
Indicative Funding Topic Value (in k€)	600		
Topic Leader	SAFRAN	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[79]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-SYS-02-32	**Development of functionalizable materials**
Short description	
Aim of the project is to develop breakthrough material constituting structure of electrical cabinets, and able to integrate mechanical and/or electrical and/or thermal elements. The expectation is to develop material(s), compliant with aeronautical application specification, and associated manufacturing processes.	

[79] The start date corresponds to actual start date with all legal documents in place.

1. Background

Mainly due to their low specific weight, relative good mechanical properties, and comfort to implement, use of composites in aeronautics is constantly increasing, including in structure of electrical cabinets.
Currently, in the aim to reduce cost of production and to functionalize structure of cabinets, investigations are conducted for integration of structural and/or thermal and/or electrical components directly into core material composing the structure.
However, honeycomb sandwich panels and monolithic composites do not enable easy integration of elements.
Thus, the objective of this project will be to specify and develop functionalizable material and associated manufacturing processes, in accordance with aeronautical specifications.

Material(s) and processes developed in the frame of this project must be:
- REACh compliant.
- optimised in terms of weight, volume and cost.
- FAR25 compliant relative to Fire Smoke Toxicity requirements.
- compliant with -55°C / +90 °C temperature.

A detailed specification will be provided at the beginning of the project.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T1	**Proposition of Materials to answer to the TM specification** The objective of this activity is to define sample geometries and associated qualification test plan (QTP) →This activity will be closed by a review: QTP review	T0+3
T2	**Samples manufacturing** The main objective of this activity consists of manufacturing the tests samples → This activity will be closed by a Machinery and Sample review and by samples delivery	T0+6
T3	**Tests on non complex samples** This activity consists of performing the QTP on Samples for verification of their conformity to specifications related to T1. →This activity will be closed by QTR (qualification test report) validation and a FSQ (File synthesis of Qualification)	T0+10
T4	**Prototype design** The main objective of this task is to check if properties obtained on non complex samples are reproducible on representative prototype. Full CAD definitions shall be provided. → This activity will be closed by a review: First Design Review (DR1)	T0+12

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T5	**Prototype manufacturing** The main objective of this activity consists of manufacturing the prototype(s) in order to provide validation samples tests.	T0+21
T6	**Final prototype(s) delivery**	T0+22
T7	**Final report of the project** The main objective of this activity consists of detailing optimized process(es) and material(s) used for realization of prototype(s), limits of the process, and feedback on manufacturing.	T0+23

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type****	***Due Date***
D1	Proposition of Material(s) and Process(es) to answer to the TM requirements	Note	T0+3
D2	Samples delivery	Samples	T0+6
D3	Qualification test report file synthesis of qualification	Report	T0+12
D4	Final prototype delivery	Prototype	T0+22
D5	Final report	Report	T0+23

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type****	***Due Date***
M1	Answer to the TM specification with proposition of functionalizable material(s)	Note	T0+3
M2	Tests report on samples and selection of candidate	Report	T0+12
M3	Design of prototype for demonstration of technology maturity	Note	T0+14
M4	Prototype delivery	Prototype	T0+22
M5	End of project	Review	T0+24

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

- Good knowledge of materials for use in aeronautics
- Capacity to use a range of different materials: polymers, foams, composite materials, etc.
- Capacity to achieve excellent reproduction of the defined samples specification
- Capacity of producing functional, end-use aerospace parts
- Capacity to use materials and to build know-how in order to reduce aerospace part weight while improving overall efficiency in meaningful and measureable ways
- knowledge and experience in the aeronautic sector
- Eco-design, Capacity to monitor and minimize use of hazardous substances in line with REACH regulation
- Capacity to design low weight components within an optimised recurring cost process

VIII. Development of autonomous, wireless, smart and low cost current sensor for monitoring of electrical lines

Type of action (RIA or IA)	IA		
Programme Area [SPD]	SYS		
(CS2 JTP 2015) WP Ref.	WP 5.2.1		
Indicative Funding Topic Value (in k€)	900		
Topic Leader	SAFRAN	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[80]	Q1 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CfP06-SYS-02-33	**Development of autonomous, wireless, smart and low cost current sensor for monitoring of electrical lines**
Short description	
The objective of the proposed activity is to develop an autonomous wireless sensor able to measure current level using local energy (no additional power supply interface), then to transmit the measured data to a remote equipment using wireless communication.	

[80] The start date corresponds to actual start date with all legal documents in place.

1. Background

In Aircraft, thousands of sensors, mostly non critical, are used to measure several parameters (as temperature, pressure, position, current, etc.). These sensors are often equipped with embedded systems for data processing and require wiring for power supply and data exchanges.

This means several hundred kilometers of wiring which imply an important weight and a high level of complexity for design, manufacturing, installation and maintenance.

In the context of the More Electrical Aircraft, this wiring complexity will continue to grow-up, consequently the wiring weight will increase. Even with today aircraft configuration, sometimes sensors cannot be installed on aircraft due to wiring constraints, for instance when the sensor location is inaccessible or when its placement requires changes of the harness design that are not affordable in retrofitting phase.
The use of wireless sensors, contributes to the reduction of wiring for power and data transmission, the containment of weight increase and the reduction of Electrical Wiring Interconnection System (EWIS) complexity.

The possibility to embed autonomous sensor in aircraft will offer considerable possibilities for the aeronautical domain. However several problems need to be solved that are related to:

- Wireless data transmission:
  - contained metallic space is not favorable for electromagnetic signal propagation,
  - interferences from and on other systems shall be avoided,
  - data exchange has to be secured,
- Power supply interface: current solutions of energy harvesting does not provide enough power for aeronautical sensor application,
- Electronic design: considering the advantages of wiring (low cost and reliability), the innovative equipment has to comply with a high level of reliability, aeronautical environmental harsh constraints and a challenging cost margins.

The purpose of the proposed activity is to develop an autonomous wireless sensor able to measure current level (nominal 100 Amps, pic 400 Amps, with an accuracy of 1%, compatible with DC and AC current (Freq. up to 1kHz)), using local energy (example: inductive coupling technology or alternative solutions), then to transmit the measured data to a remote equipment using wireless communication compatible with aeronautical constraints (range 4,2 – 4,4 GHz).

A more detailed technical specification for the autonomous sensor will be discussed with the TM at the beginning of the project.

The network communication dimension is out of scope of this activity, but design constraint shall be taken into account for the proposed design of the Wireless communication module.

The final prototype has to reach TRL5 maturity. This means that the aeronautical constraints for the qualification of the solution have to be taken into account.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T1	Functional requirement specification	T0+4 months
T2	Wireless communication module	T0+24 months From T0+4 months Duration = 20 months
T3	Power supply module	T0+16 months From T0+4 months Duration = 12 months
T4	Current sensor	T0+14 months From T0+4 months Duration = 10 months
T5	Autonomous current sensor based on modules developed in previous tasks	T0+32 months From T0+16 months Duration = 16 months
T6	Remote equipment allowing tests of solution	T0+32 months From T0+24 months Duration = 8 months
T7	Integration tests and final validation	T0+36 months From T0+30 months Duration = 6 months

T1 – Functional requirement specification

The objective is to define the requirements for the final prototype and adopt them in agreement with the end user.

The requirement analysis and the specifications will cover the following parts of the autonomous current sensor:

- Wireless data transmission module
- Power module with energy harvesting technology
- Current sensor
- Electronic card integrating all modules compliant to aeronautical constraint with low cost objective
- Receiver equipment to test the global solution.

T2 – Wireless communication module

The objective is to develop a wireless communication solution compliant to use case requirements and aeronautical qualification constraints. The power consumption of the module will be also an important factor to consider.

The technology brick shall be delivered with a minimum maturity level equal to TRL5 (i.e. design compliant to real aeronautical environmental constraints but not validated in real environment).

As recommendation, the following implementation aspects could be envisaged:

- Physical layer definition and Communication protocol compliant to aeronautical constraints and use case performance requirement
- Simulation platform to evaluate the solution and demonstrate the performance compliance
- Tests report and results analysis

T3 – Power supply module

The objective is to develop an energy harvesting solution that allows powering the sensors without use of A/C power. This solution need to be compliant with aeronautical constraints:

- Provide energy without need of specific maintenance actions between major A/C checks (10 years can be an acceptable life duration target)
- Resistant to A/C environment (pressure, thermal, vibration...)

The technology brick shall be delivered with a minimum maturity level equal to TRL5 (i.e. design compliant to real aeronautical environmental constraints but not validated in real environment).

As recommendation, the following implementation aspects could be envisaged:

- Specification of the power module for the final solution
- Demonstrator solution realization
- Tests report and results analysis

T4 – Current sensor

The objective is to develop a sensor that performs measurement of different current types (AC / DC; variable frequency; different value) in aeronautical environment. Specific constraints such as form factor will be further specified in order to comply with the A/C installation requirements.
The power consumption of the sensor will be also an important factor to consider.

The technology brick shall be delivered with a minimum maturity level equal to TRL5 (i.e. design compliant to real aeronautical environmental constraints but not validated in real environment).

As recommendation, the following implementation aspect could be envisaged:

- Specification of current sensor for the final solution
- Demonstrator solution realization
- Tests report and results analysis

T5 – Autonomous current sensor based on the modules developed in the previous tasks

The objective is to realize a demonstrator at TRL5 that integrates all modules developed in tasks 2 (wireless communication), 3 (power supply module) and 4 (current sensor).

This demonstrator shall be developed so as to answer the need of the use case defined in the specifications, but it shall be also integrate several tests means to allow validating the performance of the integrated solution as well as the performance of all its modules (communication, power, and sensor).

A TRL5 implies to design an electronic board compliant to real aeronautical environmental constraints but not validated in real environment (no D0254/D0178 compliance needs to be demonstrated).
A packaging allowing installing the sensor in real A/C conditions has to be realized.

As recommendation, the following implementation aspects could be envisaged:

- Specification and Design of demonstrator integrating all technological modules
- Demonstrator solution realization
- Tests report and results analysis

T6 – Remote equipment allowing tests of solution

The objective is to realize an equipment centralizing communication from sensors network.

This equipment shall be developed so as to allow validating the performances of sensors network realized in tasks T5. It means that no aeronautical environmental constraints have to be applied but IHM allowing an operator to determine the performances of all sensors, related to communication, power and current measurement has to be developed.

As recommendation, the following implementation aspects could be envisaged:

- Specification and Design of remote equipment
- Remote equipment realization
- Tests report and results analysis

T7 – functional tests and final validation

The objective is to create a sensors (from task T5) network integrated with the remote equipment so as to validate the compliance of the solution to the initial specification.

As recommendation, the following implementation aspects could be envisaged:

- Specification of functional tests
- tests means realization
- Tests report and results analysis

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	Global solution specification	R	T0+4months
D2	Physical layer specification	R	T0+8 months
D3	Communication protocol compliant to aeronautical constraints and use case performance requirement	D (SW)	T0+16 months
D4	Tests report and results analysis	R	T0+18 months
D5	Specification of the power module for the final solution	R	T0+8 months
D6	Demonstrator of the power module solution	HW	T0+16 months
D7	Tests report and results analysis	R	T0+18 months
D8	Specification of current sensor for the final solution	R	T0+8 months
D9	Demonstrator of the current sensor solution	HW	T0+14 months
D10	Tests report and results analysis	R	T0+16 months

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D11	Specification and Design of demonstrator integrating all technological modules	R	T0+20 months
D12	Demonstrator of global solution realization	HW	T0+30 months
D13	Integration Tests report and results analysis	R	T0+32 months
D14	Specification and Design of remote equipment	R	T0+25 months
D15	Remote equipment realization	HW	T0+31 months
D16	Tests report and results analysis	R	T0+32 months
D17	Specification of functional tests	R	T0+31 months
D18	Tests means realization	HW	T0+33 months
D19	Functional Tests report and results analysis	R	T0+36 months

*Types: R=Report, D-, HW=Hardware

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	Global solution specification	D	T0+4months
M2	Current sensor Module tests report & results analysis	R	T0+16 months
M3	Power Supply Module tests report & results analysis	R	T0+18 months
M4	Wireless Module tests report & results analysis	R	T0+18 months
M5	Global Demonstrator prototype specification	D	T0+20 months
M6	Integration Tests report and results analysis + prototype delivery	R, HW	T0+32 months
M7	Tests report and results analysis	R	T0+36 months

*Types: R=Report, D-Data, HW=Hardware

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

- Proven background and wide knowledge on:
  - civil A/C electrical architecture and equipment
  - new A/C electrical constraints linked to use of composite materials
  - A/C systems and A/C environmental qualification norms
  - Wireless communication solution with limited power consumption
  - RF antenna
  - Network communication
  - Energy harvesting technologies, and more specifically inA/C environment
  - Current measurement technology
  - electronic board development

  Capacity to design simulation platform and to implement communication protocol.
  Capacity to design and to realize a energy harvesting power supply module.
  Capacity to design and to realize a current sensor
  Capacity to design and to realize an electronic equipment integration power supply module, current sensor and wireless communication module
- Electrical functional testing capabilities and knowloedge of typical a/c environemental test (EMC, etc.)

IX. Optical hot air leak detection system proof-of-concept development

Type of action (RIA or IA)	IA		
Programme Area [SPD]	SYS		
(CS2 JTP 2015) WP Ref.	WP 6		
Indicative Funding Topic Value (in k€)	400		
Topic Leader	Liebherr	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[81]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-SYS-02-34	**Optical hot air leak detection system proof-of-concept development**
Short description	
The objective of the proposed activity is to develop a proof-of-concept for an optical hot air leak detection system to be integrated into the Topic Manager's Air system controller and to perform functional/environmental tests.	

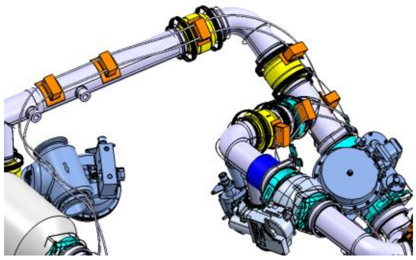
[81] The start date corresponds to actual start date with all legal documents in place.

1. Background

The proposed activity aims at developing an innovative technology for an aircraft hot air leak detection system and validating it in a representative environment (aircraft environment) up to TRL6.
Hot air leak detection systems are used to monitor, isolate and report leaks detected on aircraft, mainly on air system ducts. These functions are ensured by leak sensing elements and by a controller (electronic device). It is a critical function that is required for air systems with stringent safety, reliability and maintainability requirements. For these reasons, detection and notification to the crew are fully automatic.

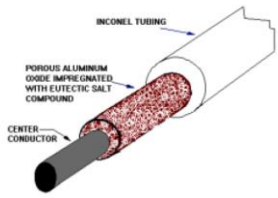
1.1 State of the Art: Current System and technology

The current system is composed of loops (sensing elements) wrapped around ducts at several locations**. The sensor has to perform in harsh environment, with high temperature (more than 400°C) and vibratory constraints.**



Two independent loops are used to minimize false leak indications and to improve the Aircraft dispatch reliability.
The controller performs overheat and monitoring functions in nominal and degraded mode:

- Overheat: Detection and localization
  . Normal Operation: overheat is confirmed by both loops.
  . Degraded Operation: overheat is detected by one loop.
- Monitoring:
  .Open circuit (rupture) detection
  .Short circuit detection (ground) and localization



The sensing elements technology consists in coaxial conductive elements separated by eutectic salt. The principle is the salt is insulating when in solid state, conductive when melted.
Limitations:

- Erroneous fault detection: The reliability of loops connector decreases in harsh environment leading to erroneous detection (by adding stray signals).
- The fault and leak localisation accuracy have to be improved as the airline service technician has to remove several access panels to find the failed element or the leak on the duct.

1.2 Fiber optics

The fiber optics technology can be used in the Hot air leak detection systems as innovative technologies for aeronautic application. It's based on the reflection of waves in the line. The optic waves propagate into a medium and when they encounter a discontinuity, part of their energy is reflected back to injection point.
The expected benefits from the optical system compared to current system are:

- Maintainability operation improvement ("fault" and leak localisation).
- EMI immune.
- Installation: Fiber optics sensing elements length is not limited.
- Connectors wear immune.

2 technologies are mainly available:

- A fiber Bragg grating (FBG) is a type of distributed Bragg reflector constructed in a short segment of optical fiber that reflects particular wavelengths of light and transmits all others. **The fiber is specific** as it is built by creating a periodic variation in the refractive index of the fiber core, which generates a wavelength-specific dielectric mirror. For these reason, the FBG increases the cost and the maintenance operations.
- The Raman technology has the advantage to not use specific fiber (which reduces the cost and maintenance operation) but add constraints on electronic parts (on the signal, as it needs high power and the receptor for high accuracy).

Most of the proposed market solutions are based on the Bragg technology: the main constraint is that the number of measurement points are very limited (around 70), while hot air leak detection system needs 1 000. The Raman technology is more flexible as the measurement points can be performed along the fiber, but less market solutions are available.

Moreover, the fiber can be composed of different materials, e.g. silica and plastic with different properties.
The plastic fiber is made out of polymer. Its main advantage is its robustness under bending and stretching. Nevertheless, the plastic fiber is only stable at medium temperature.
The silica fiber has the advantage to be used with high temperature but is less tolerant to the vibration.

Therefore, such a technology appears very promising for E-ECS application and will contribute to the improvement of availability and maintainability of the system. However, this technology is not yet mature for ECS requirements, and needs major improvements in term of performance and integration.

2. Scope of work

The expected system consists of the following components:
- One or several interrogators, which will be integrated in a Topic Manager's controller.
- Fiber optics sensors.
- Optical connectors.

The proposed activity may be organized as follows:

- **Step1: Proof of concept**

The most promising technology will be selected. The applicant will develop a solution to increase the maturity of the selected technology in order to match the functional requirements (number of measurement/electronic accuracy) and environment constraints (temperature/vibratory) in the ECS application domain.

The analysis of the architecture should be performed by the candidate and validated against requirements. The applicant will provide details on calculations and possible design alternatives.

The objective is to develop and manufacture of a Proof-of-concept demonstrator:
The purpose of this demonstrator is to validate the selected technology performance in terms of heated length resolution, spatial resolution, processing time, temperature accuracy.
The partners will then test the proof-of-concept demonstrator in a laboratory environment.

- **Step 2: Integration into a representative environment**

The proof-of-concept demonstrator will be integrated in the controller provided by the Topic Manager and, after in a test bench available in the Topic Manager facilities.
The applicant will support the integration of the demonstrator in the hot air leak detection system of the Topic Manager; it will prepare the data interface for the integration in the controller provided by the Topic Manager and will contribute to the testing activities. The demonstrator will be representative of an aircraft application.
The testing activity will consist of functional integration (leak and fault detection/localisation).
The applicant will take care of environmental testing of the sensors and the controller (separately) according to relevant requirements of EUROCAE ED14/RTCA DO 160 regulations. The applicant shall provide a complete package for a full demonstration at the Topic Manager's facilities.

The applicant will support the Topic Manager in technical report including the following elements:
- System description
- System reliability and safety analysis
- Mechanical installation recommendations
- Test procedures and reports

Tasks		
Ref. No.	***Title - Description***	***Period/Due Date***
	Selection of the most promising technology for air system demonstrator	T0+2
	Analysis and critical review of requirements and specification provided by the Topic manager	From T0+2 to T0 + 3 months
	Proof-of concept demonstrator development and manufacturing according to the specification	From T3 to T0 + 8 months
	Laboratory demonstration at partner's facilities	From T3 + 8 to T0 + 10 months
	Verification and Validation phase	From T3 to T0 + 10 months
	Optimization of the solution based on laboratory test	From T3 + 10 to T0 + 18 months
	Testing of the integrated solution with the Topic manager's controller –at Topic manager's facilities	From T3 + 18 to T0 + 20 months

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
	Design description Document	R	T0 + 6 months
	Laboratory demonstrator system test plan	R	T0 + 6 months
	Laboratory demonstrator validation report	R	T0 + 8 months
	Technical specification compliance matrix	R	T0 + 10 months
	Interface control document	R	T0 + 12 months
	Chip technical datasheet (Chip, sensors, connectors)	R	T0 + 10 months
	Hardware acceptance test results	R	T0 + 12 months

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
	Failure mode and effect analysis	R	T0 + 12 months
	Technical specification verification matrix	R	T0 + 12 months
	1 set of sensors and connectors + spares	HW	T0 + 11 months
	2 sets of chips (one for system integration testing and one for environmental testing) + spares	HW	T0 + 11 months

*Types: R=Report, D-, HW=Hardware

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
KOM	Kick-Off Meeting		T0
DDR1	Phase 1 Detailed design Review		T0 + 2 months
TRR1	Phase 1Test Readiness Review		T0 + 6 months
FTV1	Phase 1 final review and TRL validation		T0 + 8 months
DDR2	Phase 2 detailed design review		T0 + 10 months
TRR2	Phase 2 Test Readiness Review		T0 + 12 months
FTV2	Phase 2 final review and TRL validation		T0 + 24 months

*Types: R=Report, D-Data, HW=Hardware

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

- Engineering & manufacturing knowledge for optical distributed temperature sensing technology
- Engineering & manufacturing knowledge for optical miniature chips
- Experience in industrial applications for optical distributed temperature sensing systems

5. Abbreviations

TRL Technology Readiness Level

X. Computing Node for Safety Critical Applications

Type of action (RIA or IA)	IA		
Programme Area	SYS / SAT		
Joint Technical Programme (JTP) Ref.	WP 7.3 - Fly By Wire architecture for small aircraft		
Indicative Funding Topic Value (in k€)	1000		
Topic Leader	Piaggio	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[82]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-SYS-03-09	**Computing Node for Safety Critical Applications**
Short description	
Scope of this call is the definition of an Integrated Modular Avionics (IMA) architecture and the related basic building blocks to implement a highly scalable system for safety critical applications. This architecture will be based on a single Line-Replaceable Unit (LRU) providing the capabilities to communicate with other equipment through a deterministic and robust communication bus based on Ethernet protocol and a general purpose I/O interface to provide connectivity. The proposed solution should meet the requirements of low costs and data integrity in flight safety critical systems. Application or use of innovative technology resulting from previous (FP7 or other) programmes in the field of scalable architectures may be considered.	

[82] The start date corresponds to actual start date with all legal documents in place.

1. Background

Although, Fly-By-Wire is well established in large aircraft, this technology has not found its way into small aircraft. Today's technology provides well-designed network standards which fulfill the data integrity and performance requirements of flight safety critical systems at reasonable effort. The use of low-cost avionics backbone networks could enable the creation of state-of-the-art Integrated Modular Avionics (IMA) systems for small aircraft to support a Fly-by-Wire system.

2. Scope of work

Scope of this call is the definition of an Integrated Modular Avionics (IMA) architecture and the basic building blocks of a highly scalable system for safety critical applications. This architecture will be based on a single Line-Replaceable Unit (LRU) providing the capabilities to communicate with other equipment of the system through a deterministic and robust communication bus based on Ethernet protocol and a general purpose I/O interface to provide connectivity. The computational unit shall also provide the capability to connect directly with other equipment by means of standard serial line (EIA-422 and/or CAN) and it shall provide Discrete Input/Output interfaces as interlock for test/download/debug modes. The computational unit shall be capable to support ARINC-653 compliant Real-Time Operating Systems.
The short-term objective is to obtain an affordable computing platform suitable to be used as flight control computer for small aircrafts.

The activity may be organized as in the following suggested steps: after a first phase focusing on requirements (T01), the second step will be to identify the relevant technologies that are needed and to propose a conceptual design satisfying all Computing Node requirements (T02). Then the design and manufacturing of the Computing Node (T03 and T04) will be performed, followed by verification tests (T05).

Tasks		
Ref. No.	Title - Description	Due Date
T01	**System Requirements Review** The SRR will examine functional, non-functional and performance requirements, it will set the system specifications and will supervise on the compliance of the concept design, against requirements and specifications.	T0+2m
T02	**Conceptual Design** The conceptual design process will produce a high-level design concept that will be regularly evaluated to verify that the resulting design implementation will meet the requirements. This may be accomplished using items such as functional block diagrams, design and architecture descriptions, sketches etc. Main tasks will be: - High Level Architecture design of Computing Node - Generation of an High-Level description of the Computing Node - Identification of the main components (HW and SW) - Preliminary Interface Definition (HW and SW)	T0+6m

Tasks		
Ref. No.	Title - Description	Due Date
T03	**Detailed Design** Develop the detailed design of the Computing Node starting from Conceptual Design Data. Output of the detailed design phase should include: - Detailed Architecture design - Detailed Drawing of the Computing Node and of each components (including schematics and interconnection between components) - HW and SW Development - Definition of Application SW Interface	T0+12m
T04	**Implementation** The Partner, starting from the Detailed Design Data shall produce the Computing Node.	T0+18m
T05	**Acceptance Test and Verification** The acceptance test will demonstrate that the manufactured product performs in compliance with requirements and specifications.	T0+20m
T06	**Support to System Integration** During this phase the supplier will provide support to System Integrator.	T0+36m

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	System Requirement Review report	R	T0+2
D3	Computing Node conceptual design	R	T0+6
D4	Computing Node detailed design	R	T0+12
D5	Computing Node Manufacturing	D	T0+18
D6	Computing Node Test Report	R	T0+20
D7	Preliminary Project Report	R	T0+24
D8	Final Project Report	R	T0+36

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	System Requirement Review	RM	T0+2
M3	PDR of Computing Node	RM	T0+6
M4	CDR of Computing Node	RM	T0+12
M5	Computing Node design validation and Manufacturing	D	T0+18
M6	Computing Node Test Report validation	R	T0+20

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

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

- Previous experience in development and design of advanced technologies in the field of Embedded Computing.
- Proven experience in international R&T projects cooperating with industrial partners, institutions, technology centers, universities.
- Quality and risk management capabilities demonstrated through participation in international R&T projects and/or experience in the industrial environment
- Proven experience in the use of design, analysis and configuration management tools of the aeronautical industry
- Good knowledge of industrial air vehicle developments with experience in "in-flight" components and laboratory set-up for aeronautical certification.
- HW/SW development and integration capacity
- Knowledge and capabilities in test rig design
- Instrumentation data acquisition, recording and monitoring capabilities.

XI. Electrocoating process for Cr6-free surface treatment of aluminium parts

Type of action (RIA or IA)	IA		
Programme Area	ECO		
Joint Technical Programme (JTP) Ref.	WP 100.2 – Eco Design		
Indicative Funding Topic Value (in k€)	350		
Topic Leader	Liebherr	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	18	**Indicative Start Date**[83]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-SYS-03-10	**Electrocoating process for Cr6-free surface treatment of aluminium parts**
Short description	
The topic intends to explore the applicability of anaphoretic electrocoat on aircraft parts made of aluminium alloys. The aims are replacement of chromate–containing anodizing process, reduction of emissions, saving of coat and improvement of corrosion protection.	

[83] The start date corresponds to actual start date with all legal documents in place.

1. Background

Nowadays most landing gear parts made of aluminium alloys of 7000 series are protected against corrosion by surface anodising and an additional painting.

Anodising is a very complex and time intensive process that often contains hazardous substances for health and environment, which means high disposal costs. Moreover this process has a negative influence on fatigue and endurance properties of landing gear parts. Sealing processes are often used on top of the anodised surfaces. Even if it improves the corrosion resistance of the final part, it also reduces the paint adherence, which can be problematic for the resistance to stone-chipping.

The painting is also time and cost intensive. It consists in two steps:

- the application of primer to generate adhesion between the anodised layer and the paint
- the spraying of the painting/top coat.

This process has some disadventages. Most of the established primers contain hazardous substances. Spray application is based on organic solvents that have bad influence on health and environment. A high amount of paint is wasted during the spraying process since not all the sprayed paint gets sticked onto the part.

The goal of this topic is to develop an anaphoretic coating process (also known as electrocoating or e-coat) for aluminium alloys of 7000 series including the optimal pretreatment processes. This would enable the replacement of the actual anodising process and subsquent spray priming process. It shall also lead to a reduction of emissions and wasted paint and potentially increase corrosion resistance. The developed process shall respect the aeronautical standards. For example the E-Coat must be compliant with DO-160G (e.g. corrosion resistance section 14.0, fluid susceptibility section 11.0, etc.) and SAE AMS 3095A (e.g. Volatile organic content acc. To table 2, etc.) and it must not contain any substance listed in REACH Annex XIV or annex XV. Furtheremore the adhesion of the anaphoretic coating on aluminium alloys of 7000 series shall be better than the adhesion of traditional painting system on the anodised aluminium thanks to adapted pretreatment processes. The corrosion resistance of e-coated aluminium alloys of 7000 series without painting shall aim to be better than anodised aluminium alloys of 7000 series with traditional primer plus top coat. The lifetime of anaphoretic coating shall be longer than the one of traditional painting system. Influence of the coating and of the pretreatment processes on the mechanical properties of the base material shall also be minimized in order to increase the endurance of landing gear parts.

The applicant shall first lead a screening to investigate several solutions of pretreatment processes that could be adequate for the application of the anaphoretic coating on aluminium alloys of 7000 series. After screening, one or two processes shall be selected for further steps. A matrix should be defined for process paremeter development/definition and process opimtization. Several small specimen will have to be coated to assess the quality. Once small specimen are tested, the process shall be adjusted. Then a big specimen close to landing gear part dimiensions shall be successfully coated and tested. At the end of the project, the pretreatment process and the electrocoating process for aluminium alloys of 7000 series shall be clearly described and costs for a potential serial production shall be evaluated.

The coated specimens and parts during the screening and the process development should be proofed by adequate tests such as stone-chipping resistance, scratch resistance, corrosion resistance, and influence on the fatigue properties, adhesion on substrate and adhesion of top coats on the e-coat.

If this process shows promise, it shall enable a reduction of total production time. Such a process shall also enable the coating of parts with complex geometry, which could enable the development of new part design and further to a weight reduction of landing gear parts.

This call for proposal is a industrial challenge providing opportunity of competitiveness on improvement of costs, ecology, manufacturing, endurance and overhaul of parts of landing gears and flight controls for European partners of Clean Sky.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T1	Conduct a feasibility study and first screenings (coating and tests)	T0 + 3M
T2	Establish a test matrix for the development and optimization of the process aluminium alloys of 7000 series used by the TM	T0 + 4M
T3	Develop and optimize the pre-treatment process and the anaphoretic coating process	T0 + 6M
T4	Apply the pre-treatment process and the anaphoretic coating on test coupons to investigate the properties for future aircraft applications	T0 + 8M
T5	Conduct quality tests on test coupons (stone-chipping resistance / scratch resistance / corrosion resistance / fatigue influence / adhesion on substrate / adhesion of top coats on e-coat) and a comparison with standard painted parts	T0 + 13M
T6	Adjust the process regarding the previously obtained results	T0 + 14M
T7	Apply the anaphoretic coating on big specimen	T0 + 15M
T8	Perform quality test on the big specimen	T0 + 17M
T9	Conduct a cost and application study	T0 + 18M
T10	Process description for application of anaphoretic coating process & display of reached TRL Level	T0 + 18M

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Feasibility study, screening results and solution selection	Doc	T0 + 3M
D2	Test Matrix for process development	Excel Doc	T0 + 4M
D3	Coated and tested coupons	Hardware	T0 + 13M
D4	Test results of the small specimens	Doc	T0 + 13M
D5	Coated and tested big specimens	Hardware	T0 + 17M

D6	Test results of the big specimens	Doc	T0 + 17M
D7	Cost and application Study	Doc	T0 + 18M
D6	Final Report & Project Closure with process description	Doc	T0 + 18M

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M0	Kick-Off	Meeting	T0
M1	Screening results and way forward	Meeting	T0+3M
M2	Optimized process and results of the coated small specimens	Meeting	T0+13M
M3	Results of the coated big specimens	Teleconference	T0+17M
M4	End of project	Meeting	T0+18M

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

- Good background and experience in manufacturing of paintings and coatings applied on aircraft parts.
- Good background and experience in electrocoating processes especially anaphoretic coating.
- Knowledge and good work experience with aerospace requirements.
- Adequate equipment and facilities for the coating process to be investigated
- Quality control system and management capability ensuring timely execution of tasks
- Good background and experience on possible tests conducted on coatings
- Facilities to conduct tests on coated specimens/parts (either directly or through a well established partner/subcontractor).

XII. Screening and development of optimized materials (wires, potting resins and impregnating varnishes) for high temperature coils

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP6 /WP100.2		
Indicative Funding Topic Value (in k€)	500		
Topic Leader	Liebherr	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[84]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-SYS-03-11	**Screening and development of optimized materials (wires, potting resins and impregnating varnishes) for high temperature coils**
Short description	
The main objectives of this topic are: • to develop specific wires, impregnating varnishes and potting ingredients (resins) to have complete solutions for high temperature coil and qualify these ingredients, • to manufacture high temperature coils with these ingredients, integrate them in the Topic Manager's defined application and demonstrate that the solutions proposed can be industrialized. The solutions shall comply with aeronautical constraints (electrical, vibration, lifetime, manufacturing process, etc.) and sustain a minimal temperature of 300°C.	

[84] The start date corresponds to actual start date with all legal documents in place.

1. Background

Electrical Environmental Control Systems (E-ECS) feature many low power electromechanical actuators to ensure control and tuning of items such as valves. They also include motorized turbomachines with power electrical motors.
In both cases, the temperature class of coils integrated in motors or electromechanical actuators must be increased to minimize requested cooling and thus optimize both integration and mass of the system.
So, these high temperature coils can be:

- A winding of electromagnet,
- A winding of a torque motor,
- A winding of a power electrical motor.

The following figures show applications examples:

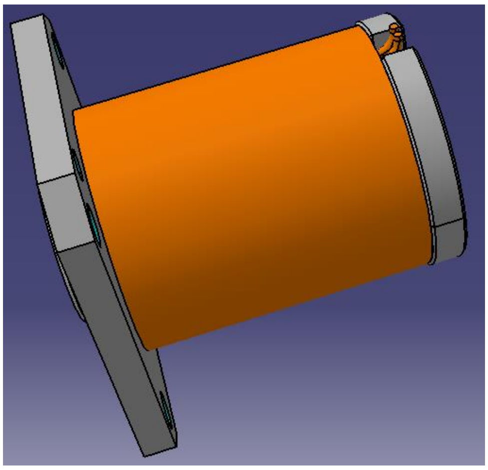


Figure 1: Coil of electromagnet

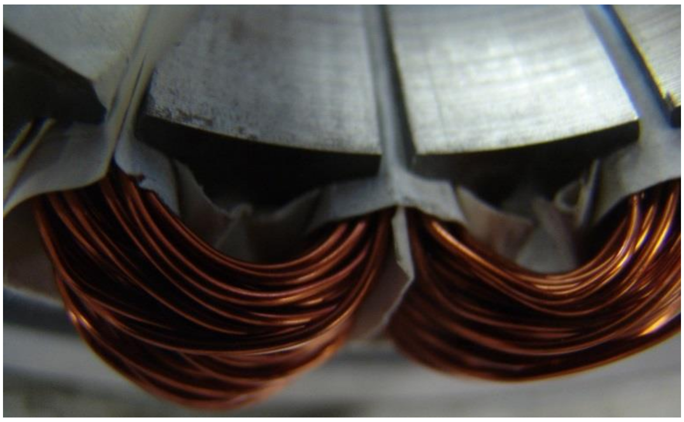


Figure 2: Motor winding

These products currently use:

- a polymer (polyamide-imide, polyimide) for the magnet wire and the impregnating varnish;
- an epoxy resin as potting ingredient.

The potting has the following function:

- To glue coils with surrounding mechanical parts in aluminium alloy or steel,
- To fill a void space around coils,
- To have a better thermal conductivity between coils and body and a good insulation to avoid electrical arcing or current leakage.

The first objective of this topic is to develop, for high temperature coil (>300°C):

- a specific varnish for the magnet wire;
- A specific varnish for the impregnation;
- a specific potting ingredient.

The new ingredients (magnet wire, impregnating varnishes, potting ingredients) shall be tested separately by the applicant(s) with the appropriate standards and methods (based on international standards and regulations) to validate the temperature class and the function. These tests shall be performed only on new ingredients selected.

The new ingredients shall be compliant with “REACH” regulation.

The new ingredients shall be applied on magnet wires and then, sample sub-assemblies of coils shall be manufactured to validate the temperature class and the function. Targeted sub-assemblies are:

- magnet wire + varnish,
- magnet wire + varnish + potting ingredient.

Tests on ingredients and sub-assemblies shall be defined and recommended by the applicant(s).

The tests on sub-assemblies shall be performed on laboratory demonstrators by the applicant(s).. After testing, the applicant(s) with the Topic Manager will select the best solutions to be integrated in the final phase of demonstration.

As a second objective, a complete and final demonstrator including a high temperature coils, integrating the newly developed ingredients, shall be manufactured, demonstrating that the solutions can be industrialized. The demonstrator shall then be fully tested to demonstrate its functionality within the targeted temperature class (>300°C).

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 1	Definition of the requirements	M3
Task 2	Trade-off: materials, manufacturing processes and qualification test method	M12
Task 3	Manufacturing, characterization and qualification of new ingredients and magnet wire	M24
Task 4	Manufacturing and qualification of coil sub-assembly samples	M30
Task 5	Manufacturing, characterization and testing of final product demonstrators	M36

Task 1: Definition of the requirements

At the beginning of the project, the Topic manager will define the following requirements:

- Conditions during service: mechanical sollicitations, environmental requirements;
- Material resistance according to RTCA/DO-160, etc.
- Electrical constraints,
- Details on ingredients function.

Task 2: Trade-off: materials, manufacturing processes and qualification test method

A trade-off shall be made on:

- **Materials:** list of ingredients compliant with the requirements defined in task 1,
- **Manufacturing processes:** according to the list of ingredients defined above and the Topic Manager part design, different manufacturing processes shall be proposed by the applicant(s),
- **Qualification test method:** a list of tests on ingredients, sub-assembly samples and on final product demonstrator shall be proposed for the qualification. A standard test adapted for high temperature (>300°C) could be used.

Several materials and manufacturing processes will be investigated during this trade-off. At the end of this trade-off, ingredients, manufacturing processes and qualification test methods that will be used during the following activities will be selected in agreement with the Topic Manager. Selection criteria shall be compliant with requirements defined in task 1, cost and process maturity.

Task 3: Manufacturing, characterization and qualification of new ingredients and magnet wire

The magnet wire and other ingredients (impregnation varnish and potting ingredient) will be manufactured according to the choices done in task 2. Several solutions will be investigated by the applicant(s) and will be proposed for a final selection to the Topic Manager.

Characterizations and qualification tests, based on the qualification test method selected in task 2, will be performed to check that the manufactured ingredients and magnet wires are compliant with the requirements defined in task 1.

It is expected that the applicant(s) manufactures and qualifies on the samples:

- several magnet wire with different diameters,
- several impregnating varnishes,
- several potting ingredients.

According to the results of the tests, the applicant(s) and the Topic Manager will selecte 2 or 3 solutions for manufacturing and qualification (task 4).

Task 4: Manufacturing and qualification of coil sub-assembly samples

Once the manufacturing process is consolidated and optimized at ingredients level, the applicant(s) will manufacture several coil sub-assemblies samples per selected solutions.

The sub-assembly could be:

- Magnet wire + impregnating varnish parts (twisted pairs…),
- Potting ingredient + plate (aluminium and steel),
- Magnet wire + impregnating varnish+ potting ingredient.

Then, qualification tests, based on the qualification test method selected in task 2, will be performed to check that the manufactured sub-assemblies samples are compliant with the requirements defined in task 1.

Task 5: Manufacturing, characterization and testing of final product demonstrators

This task is the final phase which will allow to validate the solutions in a representative environement. The final product demonstrator design will be provided by the Topic Manager. The new magnet wire and ingredients qualified will be integrated in these final product demonstrators. For example, the product demonstrators could be a coil in a body, both being glued with the potting ingredient.

For this task, 2 demonstrators will be manufactured and tested by the candidate in its facilities in order to validate the manufacturing process. Then 2 other demonstrators could be manufactured by the applicant(s) to be tested by the Topic Manager in its facilities.

The applicant(s) will manufacture, characterize and check the quality of these different demonstrators applying the qualification test method selected in task 2.

Technology and Manufacturing readiness level objectives

By the end of the project, TRL6 and MRL7 shall be reached:

- *TRL 6 means that a representative prototype (final product demonstrator) shall be manufactured and tested in a relevant environment.*
- *MRL7 means that the manufacturer shall have the capability to produce the prototype in a production representative environment.*

A business case shall be proposed by the applicant(s) to evaluate serial cost of the future products (including RC/NRC).

The applicant(s) shall demonstrate its (their) capacity to transfer the process to an industrial scale and to ensure aeronautical production rates. In order to achieve this objective, a roadmap and associated risk analysis to reach full industrialisation is requested.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Definition of requirements	R	M3
D2	Materials, manufacturing processes and qualification test method trade-off synthesis report	R	M12
D3.1	Manufacturing of ingredients and magnet wire	S	M22
D3.2	Characterization and qualification tests of ingredients and magnet wire: synthesis report	R	M24
D4.1	Manufacturing of coil sub-assemblies	S	M28
D4.2	Qualification of sub-assemblies and definition of success criteria for process validation	R	M30
D5.1	Manufacturing of final product demonstrators	D	M34
D5.2	Characterization and testing of final demonstrators: synthesis report including process manufacturing validation with success criteria	R	M36
D5.3	Business case	R	M36
D5.4	Roadmap and associated risk analysis to reach full industrialisation	R	M36

Milestones (when appropriate)			
Ref. No.			
M1	Selection of materials, manufacturing processes and qualification test method following trade-off results	Milestone	M12
M2	Ingredients and sub-assemblies design qualified	Milestone	M24
M3	Final prototypes design validated	Milestone	M34

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

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

- Extensive experience and strong knowledge on design and test of electrical insulation ingredients (impregnating varnishes, potting resin…)

- Extensive experience and capabilities for characterisations of ingredients and for qualification of electrical insulation ingredients based on standard method.
- Extensive experience and strong knowledge on magnet wire manufacturing.
- Facilities for implementing the processes in an industrial scale and ensuring aeronautical production rates.

XIII. Assessment of Partial Discharge and breakdown behaviour of electric insulation materials for very high voltage gradients

Type of action (RIA or IA)	RIA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP 100.2		
Indicative Funding Topic Value (in k€)	400		
Topic Leader	Liebherr	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[85]	Q1 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP06-SYS-03-12	**Assessment of Partial Discharge and breakdown behaviour of electric insulation materials for very high voltage gradients**
Short description	
The use of new switching technologies in aerospace systems may expose machines and other wound components to increased voltage gradients. The proposed work aims at determining the impact of higher voltage gradients on insulation systems and defining suitable and effective testing methods.	

[85] The start date corresponds to actual start date with all legal documents in place.

1. Background

The use of high speed switching devices is expected to support the development of power electronic systems with lower losses and improved power density. However, devices based on technologies such as SiC produce voltage gradients that have a negative impact on the performace of high voltage insulation systems. As such, there is a need to assess if state-of-the-art insulation materials of machines and power electronic components are suitable for future applications using higher supply voltages and higher switching gradients. The proposed activity will encopass:

- The analysis and the experimental assessment of state-of-the-art insulation materials and systems
- The development of methods for the verification / qualification of insulation materials (accounting for aerospace environmental conditions and future / increased high voltage gradients).
- Drawing up design guidelines and design optimization advices(including materials) supporting the development of machines operating with wide-bandgap switches in aerospace environmental conditions.

The activity will addressed representative aerospace environmental conditions and dependency on AC supply voltage (3 phase 115Vrms vs. 3 phase 230Vrms) with a maximum DC link voltage of 1000V. Slew rates of up to 20kV/µs, should be considered as well as increased voltage levels that may be faced in future aircraft designs.

2. Scope of work

The applicant shall perform following activities:

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T1	**Assessment Of Voltage Gradients / Magnitudes Observed Within Insulation Systems** This task will use modelling techniques to assess the voltage gradients and the magnitudes observed in insulation systems for typical converter – cabling – machine systems. It is known that the length of cabling connected between a converter and a machine has a significant impact on the voltage observed at the machine. With power electronic devices capable of switching at higher speeds, this task should confirm the magnitude and shape of the voltages appearing through different parts of the power electronic system. This task should include an assessment of the voltage distribution within a typical electrical machine and should examine the impact of key parameters such as the number of turns, the winding method used and the stator length. Experimental measurements should be used if considered appropriate. The task should identify measures that can be taken to reduce the voltage gradient at the electrical machine without compromising the performance of the power electronic converter.	M12

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T2	**Assessment Of Partial Discharge And Breakdown Behaviour Of Components Exposed To High Voltage Gradients** This task will examine the impact of increasing slew rates on the partial discharge and breakdown behaviour of typical components used in the aerospace environment (including the impact of varying pressure, humidity and temperature). It should include an elaboration on the performance of electrical insulation materials typically used in power electronic systems as a function of rise time and suggest a development opportunities to progress beyond the state of the art. A suitable test programme shall examine the performance of insulation systems in electrical machines and connecting cables / connectors. The task should identify the insulation types best suited to manage high voltage gradients and ideally capable of delivering partial discharge free components. The task should also identify methods for the verification and qualification of new insulation systems.	M18
T3	**Lifetime Characterisation Of Components Exposed To High Voltage Gradients** This task is expected to quantify the impact that higher voltage gradients will have on the lifetime of electrical machines and the connecting cables / connectors. The task should focus on systems that cannot be guaranteed partial discharge free and that will likely have a limited life. The task should identify the impact of higher voltage gradients on the lifetime of electrical insulation and quantify the impact of any measures identified in tasks 1 and 2. Effect of managing the voltage gradients through alternative designs of insulation or winding systems may also be analysed. This analysis may lead to an update of the defined verification / qualification methods defined in task 2. The task should provide recommendations for the design of insulation systems when using high voltage gradient systems.	M24

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	Model to assess voltage gradient and magnitudes within insulation systems including related report of T1 results	R	T0 + (12 months)
D2	Report of PD and breakdown behaviour of components exposed to high voltage gradients including verification methods; including results of T2	R	T0 + (18 months)
D3	Report of lifetime characterization of components exposed to high voltage gradients including design recommendations; including results of T3	R	T0 + (24 months)

*Types: R=Report, D-, HW=Hardware

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***

*Types: R=Report, D-Data, HW=Hardware

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

- Expertise in partial discharge and other forms of high voltage measurement within the aerospace environment
- Equipment suitable of assessing the partial discharge behaviour of insulation systems exposed to high slew rates (up to 20kV/us) and at pressures down to 10,000Pa combined with temperatures between -50^{o}C and 150^{o}C
- Previous work in the area of high speed switching devices
- Capability to model and, if required, experimentally verify the distribution of voltage gradients and magnitudes within a typical aerospace power electronic system

Knowledge of relevant standards in the field of high voltage systems used in aerospace

5. Abbreviations

HVDC	High Power Direct Current
SiC	Silicon Carbide
HW	Hardware
PD	Partial discharge