Annex II:
3rd Call for Proposals (CFP03):
List and Full Description of Topics

Call Text

- February 2016 -

Index

Overview of number of topics and total funding value per SPD

Area	No. of topics	Funding* (M€)
IADP Large Passenger Aircraft	12	9,63
IADP Regional Aircraft	3	5,05
IADP Fast Rotorcraft	9	9,50
ITD Airframe	17	11,53
ITD Engines	10	13,00
ITD Systems	12	9,05
Small Air Transport (SAT) Transverse Area	(1)	(1,10)
ECO Transverse Area	(5)	(2,25)
Technology Evaluator 2	0	0
TOTAL	63	57,76

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 (CFP03)

Identification Code	Title	Type of Action	Value (Funding in M€)
JTI-CS2-2016-CFP03-LPA-01-12	High cycle fatigue prediction methodology for fiber reinforced laminates for aircraft structures in CROR environment – development and validation	IA	0,400
JTI-CS2-2016-CFP03-LPA-01-13	Manufacturing of prototype elements for hybridation of titanium and epoxy resin - Characterisation of the Titanium TiCP40 - CFRP adhesive joint	RIA	0,700
JTI-CS2-2016-CFP03-LPA-01-14	Automated injection RTM system process based in innovative sensor technologies in a low cost smart manufacturing tooling prototype and any tooling involved in the manufacture or the validation of the structure	IA	1,000
JTI-CS2-2016-CFP03-LPA-01-15	High Fidelity time-accurate CFD Simulations	RIA	0,300
JTI-CS2-2016-CFP03-LPA-01-16	Aerodynamic Isolated and Installed Methods for UHBR Adaptable Area Nozzles	IA	1,100
JTI-CS2-2016-CFP03-LPA-01-17	Windtunnel test for flow control at the engine/pylon with a representative aircraft configuration under fully realistic flow conditions	RIA	0,800
JTI-CS2-2016-CFP03-LPA-02-08	High production rate composite Keel Beam feasibility	IA	0,600
JTI-CS2-2016-CFP03-LPA-02-11	Structural energy storage and power generation functionalities in multifunctional composite structures	RIA	1,130
JTI-CS2-2016-CFP03-LPA-02-12	Development of System Components for automated Cabin and Cargo Installation	IA	1,250
JTI-CS2-2016-CFP03-LPA-02-13	Design for Automated Installation of Linings and Hatracks in Cabin and Cargo	IA	0,750
JTI-CS2-2016-CFP03-LPA-02-14	Assembly Planning and Simulation of an Aircraft Final Assembly Line (FAL)	IA	0,500
JTI-CS2-2016-CFP03-LPA-03-07	Secured and performant wireless connection based on light (LiFi) for EFB, headset and other pilot connected devices	IA	1,100
JTI-CS2-2016-CFP03-LPA		**12 topics**	**9,630**
JTI-CS2-2016-CFP03-REG-01-02	Green Turboprop configuration - Natural Laminar Flow adaptive wing concept aerodynamic experimental validation (WTT2)	IA	2,250
JTI-CS2-2016-CFP03-REG-01-03	Aileron Actuation Subsystem using EMAs	IA	1,100
JTI-CS2-2016-CFP03-REG-01-04	Development and delivery of a flexible assembly system based on reverse engineering, tolerance analysis and Determinant Assembly Approach of wing box	IA	1,700
JTI-CS2-2016-CFP03-REG		**3 topics**	**5,050**

Identification Code	Title	Type of Action	Value (Funding in M€)
JTI-CS2-2016-CFP03-FRC-01-02	Development and demonstration of a high power density homokinetic drive joint for civil rotor applications	IA	0,750
JTI-CS2-2016-CFP03-FRC-01-07	Next generation smart active inceptors for a civil tiltrotor	IA	1,500
JTI-CS2-2016-CFP03-FRC-01-08	High Speed HVDC Generator/Motor	IA	1,000
JTI-CS2-2016-CFP03-FRC-01-09	Power Distribution	IA	1,500
JTI-CS2-2016-CFP03-FRC-01-10	Next Generation Fuel Storage System	IA	1,000
JTI-CS2-2016-CFP03-FRC-02-09	Light weight, impact resistant, canopy for fast compound rotorcraft	IA	1,500
JTI-CS2-2016-CFP03-FRC-02-11	Design and Realization of equipped engine compartments including cowling for a fast compound rotorcraft	IA	1,250
JTI-CS2-2016-CFP03-FRC-02-15	Advanced Health Monitoring System for next generation materials	IA	0,500
JTI-CS2-2016-CFP03-FRC-02-16	Electrical Components	IA	0,500
JTI-CS2-2016-CFP03-FRC		**9 topics**	**9,500**
JTI-CS2-2016-CFP03-AIR-01-15	Functional top coat for natural laminar flow	IA	0,680
JTI-CS2-2016-CFP03-AIR-01-16	Design Guide Lines and Simulation Methods for Additive Manufactured Titanium Components	RIA	0,800
JTI-CS2-2016-CFP03-AIR-01-17	Orbital Drilling of small (<10mm diameter) holes, standardly spaced with aluminium material in the stack.	RIA	0,500
JTI-CS2-2016-CFP03-AIR-01-18	Research and development of a compact drilling and fastening unit suitable for a range of standard 2 piece fasteners	RIA	0,500
JTI-CS2-2016-CFP03-AIR-01-19	Hybrid Aircraft Seating Requirement Specification and Design - HAIRD	IA	0,250
JTI-CS2-2016-CFP03-AIR-02-17	Flexible Test Rig of Aircraft Control Surfaces powered by EMAs	IA	0,510
JTI-CS2-2016-CFP03-AIR-02-18	Prototype Tooling for subcomponents manufacturing for wing winglet	IA	0,600
JTI-CS2-2016-CFP03-AIR-02-19	Prototype Tooling for Sub-Assembly, Final Assembly and Transport of the Morphing Winglet and Multifunctional Outer Flaps of the next generation optimized wing box	IA	0,810
JTI-CS2-2016-CFP03-AIR-02-20	Low cost Fused Filament Fabrication of high performance thermoplastics for structural applications	RIA	0,350
JTI-CS2-2016-CFP03-AIR-02-21	Innovative Tooling Design and Manufacturing for Thermoplastic Stringers and High Integration	IA	1,200

Identification Code	Title	Type of Action	Value (Funding in M€)
JTI-CS2-2016-CFP03-AIR-02-22	Adaptive multifunctional innovative Test Rigs for both structural test of multidimensional and multishape panels and structural tests on Tail unit	IA	0,350
JTI-CS2-2016-CFP03-AIR-02-23	Automation of hand lay-up manufacturing process for composite stiffeners	IA	0,120
JTI-CS2-2016-CFP03-AIR-02-24	Tests for leakage identification on Aircraft fluid mechanical installations	IA	0,260
JTI-CS2-2016-CFP03-AIR-02-25	Development and demonstration of materials and manufacturing process for high structural damping composite beams for civil rotor and airframe applications	IA	0,500
JTI-CS2-2016-CFP03-AIR-02-26	Development of innovative automated fiber placement machine for composite fuselage manufacturing with high performance hybrid materials	IA	2,700
JTI-CS2-2016-CFP03-AIR-02-27	Development, fabrication, verification and delivery of innovative and flexible system for automated drilling and fastener insertion on fuselage barrel	IA	0,900
JTI-CS2-2016-CFP03-AIR-02-28	Development of equipment for composite recycling process of uncured material	RIA	0,500
JTI-CS2-2016-CFP03-AIR		**17 topics**	**11,530**
JTI-CS2-2016-CFP03-ENG-01-05	Optimisation of sensor and associated data acquisition system for blade behaviour	RIA	1,800
JTI-CS2-2016-CFP03-ENG-01-06	Very high loaded planet bearings enabling technologies	IA	0,500
JTI-CS2-2016-CFP03-ENG-01-07	Advanced mechatronics devices for electrical management system of Turboprop	RIA	0,900
JTI-CS2-2016-CFP03-ENG-01-08	Advanced Bearings for Turboprop engine	IA	0,500
JTI-CS2-2016-CFP03-ENG-01-09	Integrated air-oil cooling system	IA	0,700
JTI-CS2-2016-CFP03-ENG-02-04	Automated full faced measurement of complex geometries	RIA	1,200
JTI-CS2-2016-CFP03-ENG-03-09	Orbiting Journal Bearing Rig	IA	1,100
JTI-CS2-2016-CFP03-ENG-03-10	Innovations in Titanium investment casting of lightweight structural components for aero engines	RIA	0,800
JTI-CS2-2016-CFP03-ENG-03-11	Aerodynamic rigs for VHBR IP Turbine	IA	2,500
JTI-CS2-2016-CFP03-ENG-03-12	Development of intelligent oil system enablers for large VHBR engine oil lubrication and heat management systems	RIA	3,000

Identification Code	Title	Type of Action	Value (Funding in M€)
JTI-CS2-2016-CFP03-ENG		10 topics	13,000
JTI-CS2-2016-CFP03-SYS-01-02	Mems Accelerometer– Maturity Assessment And Improvement	IA	1,000
JTI-CS2-2016-CFP03-SYS-02-14	Development of electromechanical actuators and electronic control units for flight control systems	RIA	1,600
JTI-CS2-2016-CFP03-SYS-02-15	Smart oil pressure sensors for all oil cooled starter/generator	IA	0,600
JTI-CS2-2016-CFP03-SYS-02-16	Optimization two phases cooling solution using micro pump brick	IA	0,800
JTI-CS2-2016-CFP03-SYS-02-17	innovative pump architecture for cooling electrical machine	IA	0,800
JTI-CS2-2016-CFP03-SYS-02-18	Eco Design: Injection of thermoplastic reinforced with long fibers (carbon, glass, Kevlar…) for scroll reinforcement	IA	0,500
JTI-CS2-2016-CFP03-SYS-02-19	Eco Design: Composite functionalization: thermal and electrical conductivity	RIA	0,500
JTI-CS2-2016-CFP03-SYS-02-20	Eco Design: Screening and development of optimized materials (wires, resins and varnishes) for high temperature coils	IA	0,500
JTI-CS2-2016-CFP03-SYS-02-21	Model-Based identification and assessment of aircraft electrical and thermal loads architecture management functions	RIA	0,900
JTI-CS2-2016-CFP03-SYS-03-04	Low Power De-Icing System suitable for Small Aircrafts	IA	1,100
JTI-CS2-2016-CFP03-SYS-03-05	Eco Design: High efficient non-structural landing gear parts based on advanced carbon fiber material systems and highly automated production technologies for helicopter and aircrafts.	IA	0,400
JTI-CS2-2016-CFP03-SYS-03-06	Eco Design : Electrocoating process for Cr6-free surface treatment of aluminium parts	IA	0,350
JTI-CS2-2016-CFP03-SYS		12 topics	9,050

1. Clean Sky 2 – Large Passenger Aircraft IAPD

I. High Cycle Fatigue Prediction Methodology for Fiber Reinforced Laminates for Aircraft Structures in CROR Environment – Development and Validation

Type of action (RIA or IA)	IA		
Programme Area	LPA		
Joint Technical Programme (JTP) Ref.	WP 1.2.1 - Advanced Engine and Aircraft Configurations		
Indicative Funding Topic Value (in k€)	400 k€		
Duration of the action (in Months)	24 months	Indicative Start Date[1]	01 2017

Identification	Title
JTI-CS2-2016-CFP03-LPA-01-12	High cycle fatigue prediction methodology for fiber reinforced laminates for aircraft structures in CROR environment – development and validation
Short description (3 lines)	
For the design of airframe structure regions facing CROR blades, the reinforcement of CFRP has to be laid out dedicatedly in terms of fatigue resistance. Fatigue shall be described by appropriate models in simulation and verified in correlated testing.	

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

1. Background

WP 1.2 deals with the validation of a critical disruptive technology, required to secure safe and efficient CROR integration on rear end mounted aircraft, at representative scale, to reach TRL 6. The critical challenges are safety (Uncontained Engine Rotor Failure (UERF), high dynamic loads via a large pylon, vibrations and noise. It requires to re-design the systems and structural architecture of the aircraft since it has a strong impact on the center of gravity of the aircraft.

A rear end demonstrator will be designed and manufactured to provide a representative framework to:

- Demonstrate a full scale rear-end with representative static, fatigue and dynamic loads.
- Demonstrate engine integration compliance with certification rules
- Validate CFRP structure and system integration concept for an advanced engine
- Demonstrate fuselage vibration and acoustics response
- Development of test capabilities both physical at full scale and virtual for various purposes such as static, fatigue, vibrations, impact, system integration and operability.
- Develop, mature and demonstrate concepts for structural health monitoring.
- Demonstrate repair technologies.

Any considered shielding strategy for the airframe will consider not only impacts by uncontained rotor failure but also impacts caused by ice shedding, tyre debris or hail and bird strike as well as noise shielding requirements. Therefore efficient measures for structural shielding reinforcement based on innovative material technologies and architectures, including noise shielding functionalities have to be developed.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T01	Sound source and amplification setup	***03/2017***
T02	Temperature and humidity sensitivity	***12/2017***
T03	Physical analysis of fatigue effects	***03/2018***
T04	HCF extension to fatigue master curves	***06/2018***
T05	FEA of fracture and damage	***09/2018***
T06	Model validation	***12/2018***

The objective of this project is the development and validation of an advanced methodic framework, including testing methodology for predicting the long-term fatigue life of multi-ply tape laminates for the use in aircraft structures loaded e.g. by CROR sound pressure. In the frame of the project to be proposed complementary to the tasks in WP1.2.1 alternative material as well as modified load characteristics have to be applied which is absolutely essential for validation of the extension of the methodology. The development work will consist of experimental tests, physical analysis and numerical simulation. The experimental tests will specifically be designed and performed as required by this development work starting from specimen fabrication out of material samples provided by the partners of the CleanSky2 LPA IADP.

An explicit requirement to the applicant with **T01** is to provide appropriate sound source and amplification means for the test setup at Fraunhofer IBP in Stuttgart. A portion of 80 k€ has to be reserved for that task in the project.

The fatigue prediction methodology shall be developed based on an existing approach to accelerated lifetime predictions of carbon fiber reinforced laminates, whose general feasibility has already been demonstrated experimentally. The development will expand the existing approach systematically such that the number of structural configurations, load conditions, and environmental effects covered and accounted for by the testing methodology is increased by the following technical achievements:

T02 - Temperature and moisture sensitivity: The fatigue model will be able to predict the lifetime at arbitrary levels of temperature and moisture and accounts for the effects of self-heating at fiber reinforced materials most relevant aircraft structures for CROR and ATP engine mounting environment. The respective experimental tests shall include single mode as well as combined tests providing for a comprehensive characterization of the material behavior with respect to its temperature dependent transient, dynamic and fatigue contributions. The tests have to be performed by dedicated equipment supplemented by in-situ contact-less measurement features applying digital image correlation, DIC, that allows a precise quantification of the multi-dimensional stress and strain fields occurring in the specimen during tests.

T03 - The physical analysis will include destructive and non-destructive techniques providing thorough information on the microstructure of the specimens at all stages of the tests. All experimental data, i.e., the static and the transient data of the stress and strain fields as well as the micro structural information, will be captured by parametric 3-D finite element models (**T05**) and each test will be replicated by a numerical simulation at all its phases - including the failure of the sample if applicable. Hence, concepts of fracture and damage mechanics shall be applied besides those of nonlinear continuum mechanics to determine the effects of self-heating and moisture and temperature sensitivity and set them in relation to the known structural and environmental effects on the fatigue lifetime (e.g., ply types and orientation in the stack, load direction, ambient temperature and humidity etc. By means of closed loop combination of experimental tests, physical analyses, and numerical simulations, all effects shall be studied and analyzed thoroughly that contribute to the fatigue life of extremely loaded aircraft structures made of the material under investigation even in configurations not tested explicitly (i.e., in different stack configurations).

T04 - HCF approach: The fatigue model will be expanded to be able to predict the lifetime of CFRP at higher frequency loads (HCF – high cycle fatigue) to represent high sound pressure loading from CROR

T06 - The validity of each methodology enhancement shall be demonstrated. The outcome of the investigation will be an Excel spread-sheet table including the resulting fatigue master curves and shift factors that allow accounting for all abovementioned effects and will be validated in this task.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D01	Sound source and amplification – Setup of sound source and amplifier @ IBP Stuttgart	HW	03/2017
D02	Feasibility Report - Demonstration of the feasibility of the tests, the physical analysis, and the numerical simulation according to the *preexisting* methodology based on material samples provided by the partners within CS2 LPA IADP	R	03/2017
D03	Validation of concept - Demonstration of the feasibility of the concepts developed for expanding the methodology towards including the effects of HCF, temperature and humidity	R	06/2017
D04	Temperature and humidity expansion - Methodology enhancement with respect to self heating and moisture effects is developed and validated	R	12/2017
D05	HCF expansion - Demonstration of the feasibility of the concepts developed for expanding the methodology towards including the effects of HCF, temperature and humidity	R	06/2018
D06	Final report	R	12/2018

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M01	Sound source and amplification – Setup of sound source and amplifier @ IBP Stuttgart	HW	03/2017
M02	Methodology enhancement with respect to temperature and humidity (developed and validated)	R	12/2017
M03	Methodology enhancement with respect to HCF effects (developed and validated)	R	06/2018

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

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

II. Manufacturing of prototype elements for hybridation of titanium and epoxy resin - Characterisation of the Titanium TiCP40 - CFRP adhesive joint

Type of action (RIA or IA)	RIA		
Programme Area	LPA		
Joint Technical Programme (JTP) Ref.	WP1.4		
Indicative Funding Topic Value (in k€)	700 k€		
Duration of the action (in Months)	24 months	**Indicative Start Date[2]**	Q1 2017

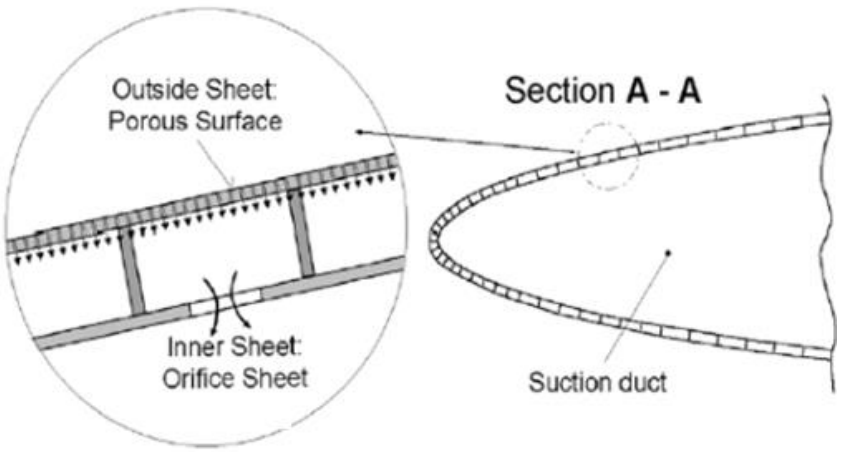
Identification	Title
JTI-CS2-2016-CFP03-LPA-01-13	**Manufacturing of prototype elements for hybridation of titanium and epoxy resin - Characterisation of the Titanium TiCP40 - CFRP adhesive joint**
Short description (3 lines)	
The objective of this call for proposal is the manufacturing, development and experimental testing for the characterisation of interlaminar adhesive properties between the titanium-composite joint of the HLFC (hybrid laminar flow control) system.	

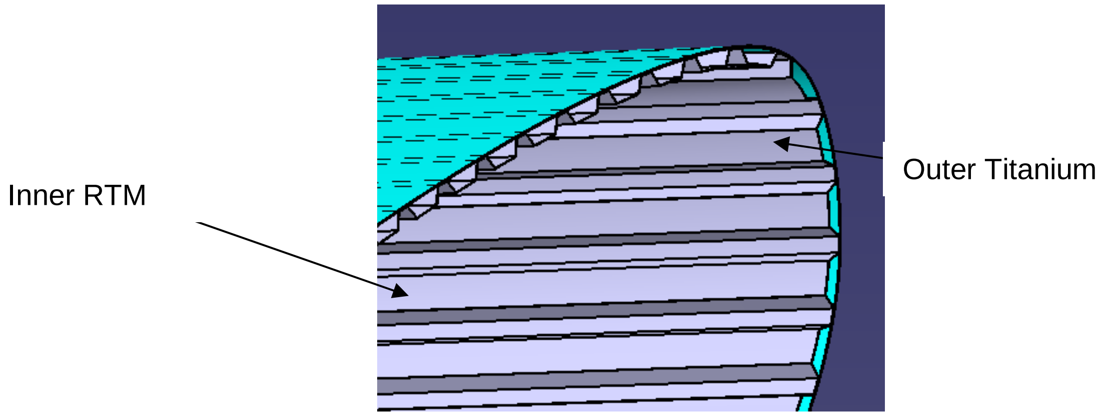
[2] The start date corresponds to actual start date with all legal documents in place.

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 extrados surfaces. The technique has the potential of considerable drag reduction and consequently saving 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 design and integration of a prototype HLFC system for test and validation. The design introduces an advanced HLFC concept, incorporating a perforated titanium cover to the composite Leading edge. The laminar flow at the profile is maintained by a suction integrated in the system. The diagram below illustrates the concept.





The titanium cover (very thin layer,TBC) and the composite leading edge are joined through an adhesive bound. This area is considered critical and failure of this union must be investigated for certification. In addition, characterisation of the test adhesive properties is needed for later on numerical simulation purposes.

The call for proposal is broken down into several tasks:

- Specimen Manufacturing
- Static/Quasi-static experimental testing
- Medium/High strain rate (dynamic) experimental testing
- Fatigue experimental testing

2. Scope of work

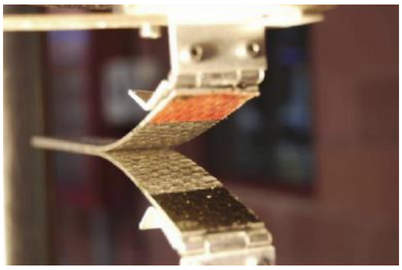
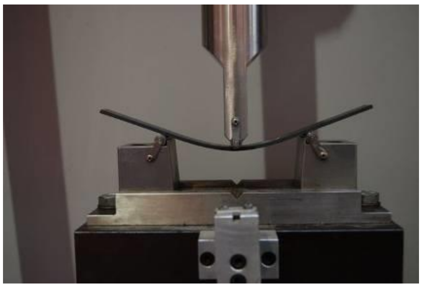
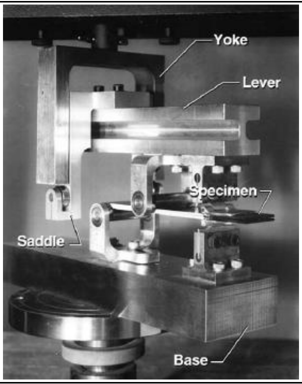
Tasks		
Ref. No.	***Title – Description***	***Due Date***
T0	Global test plan document which cover all test	***T0+M3***
T01	Test specimen manufacturing and machining to test dimensions	***T0+M6***
T02	Static test and characterisation	***M12***
T03	Dynamic test and characterisation	***M15***
T04	Fatigue test and characterisation	***M24***

The objective of this project is the manufacturing, development and experimental testing for the characterisation of interlaminar adhesive properties between the titanium-composite union of the HLFC system.

T01- Test specimen manufacturing and machining to test dimensions. The composite CFRP of the design concept is manufactured using carbon fabric by means of RTM Out of Autoclave (OoA) process.

The applicant must provide at least 3 types of union technology for the joint between CFRP and titanium sheet. These Coupons will be manufactured and cut to testable sizes. The applicant must provide a sufficient amount of test specimen for the testing process (5 specimens per test for each type of union technology)

T02- Static experimental test and characterisation. The static experimental tests are carried out under quasi-static loading conditions. Tests results shall provide a comprehensive characterisation of the adhesive material properties for its respective tested modes. The tested modes are described as follows:

		
Mode 1. *DCB test.*	Mode 2. *ENF test*	Combined. *MMB test*

The tests to be considered under different environmental hot/wet (HW) conditions of 70 ºC and -55 ºC. Test standard definitions are provided in the table below.

Experimental test	Test Name	Standard Numbering	Output result
Static Interlaminar Toughness	Mode I Fracture Energy	AITM 1.0005	G1c
	Mode II Fracture Energy	protocol ESIS-TC4-2008	G2c
	Mixed Mode Fracture Energies	ASTM D 6671/D 6671M-03	G2/(G1c+G2c) at B= 0.25, 0.5 and 0.75

<u>T03- Dynamic experimental test and characterisation.</u> The dynamic experimental tests are carried out under medium/high strain rate of 2 velocities. Characterisation of the adhesive material properties shall be obtained from the tested modes. These are the same modes described in the static experimental test (T02).Environmental Hot/ wet and temperature conditions must be considered for 70 ºC and -55 ºC. The test standard definitions are described as follows:

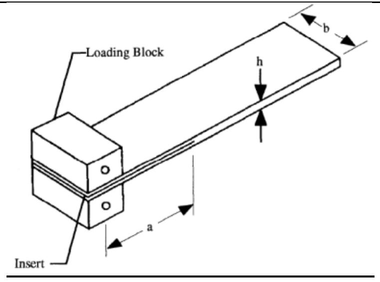
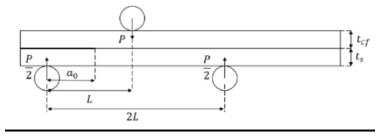
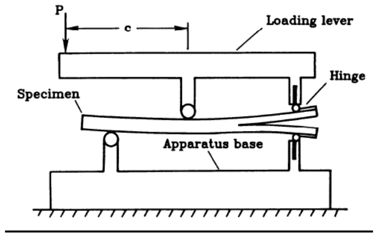
Experimental test	Test Name	Standard Numbering	Output result
Dynamic Interlaminar Toughness	Mode I Fracture Energy Speed 1 and 2	Same tooling different load introduction speeds	G1c shape variation from Static to Dynamic
	Mode II Fracture Energy Speed 1 and 2	Same tooling different load introduction speeds	G2c shape variation from Static to Dynamic
	Mixed Mode Fracture Energies Speed 1 and 2	Same tooling different load introduction speeds	G2/(G1c+G2c) at B= 0.25, 0.5 and 0.75 at speed 1 and 2

The physical analysis will include destructive and non-destructive techniques providing thorough information on the microstructure of the specimens at all stages of the tests.

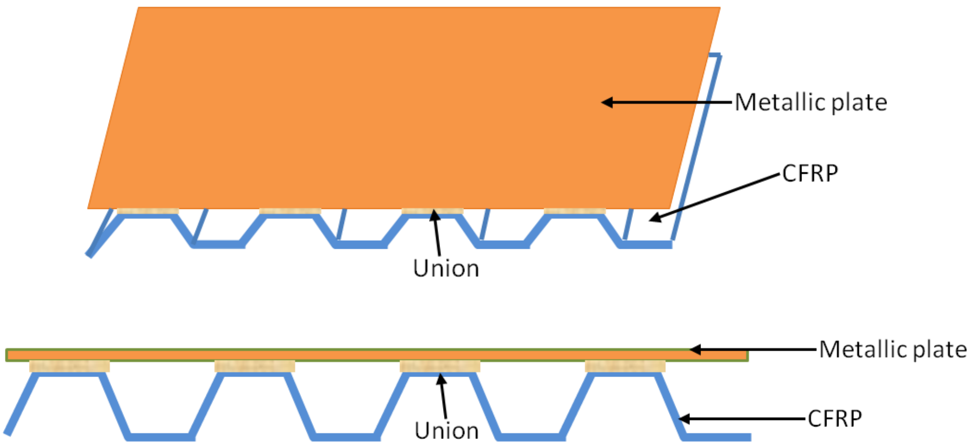
<u>T04- Fatigue experimental test and characterisation</u>. Testing of the specimen is carried out under cyclic loading. The testing will focus on destructive and non-destructive techniques providing specimens inspections at all stages of the tests. Defects will be introduced in the specimen prior testing. Tests must consider Environmental HW conditions for 70ªC and 55 ºC. Fatigue testing will be separated into 2 stages:

1. <u>Coupon tests</u> –Specimens manufactured from T01 will be tested under different fatigue loads. Fatigue

fracture toughness and delamination characterization tests have to be developed for double cantilever beam (DCB) mode I loading, end-notch fixture (ENF) for mode II loading and mixed-mode bending (MMB) tests. The objective is to determine the SN curves of the union, onset and crack growth rate of the specimens have to be determined.

		
Mode 1. *DCB test.*	Mode 2. *ENF test*	Combined. *MMB test*

2. <u>Validation test</u>- A bigger size validation specimen will be manufactured and tested under cyclic fatigue and considering the chosen manufacturing process. The load cases will be defined in the negotiation phase and the number of cycles for the test will be defined later (typically 50000 cycles). The diagram below show the schematic representation of the specimen that will be used for the fatigue validation phase. The applicant will provide all tooling (design and manufacturing) necessary for performing the test



Note: all tools (design and manufacturing) as well as the required materials necessary to carry out the mentioned tests: static, dynamic and fatigue test will be responsibility of the applicant.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D01	Test plan definition	R	T0+M3
D02	Static test results	R	M12
D03	Dynamic test results	R	M15
D04	Fatigue test results	R	M18

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M01	Test plan approval	R	T0+M3
D02	Static test results review	R	M12
D03	Dynamic test results review	R	M15
D04	Fatigue test results review	R	M18

The proposed delivery schedule might be adjusted to fit in an activity plan of 24 months instead of 18 months.

Any proposal demonstrating the capability to perform the work in a shorter duration (18 months) with a low level of risk will be positively considered.

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

- The applicants should have a strong knowledge and experience in mechanics and characterization of composite materials.
- Specifically, the applicant must have:
  - A material characterization lab with sample preparation workshop, universal and DMA (Dynamic Mechanical Analysis) testing equipment for all test modes mentioned in the task description featuring temperature chambers (-55°C to 70°C) providing for moisture control (up to 85%r.h.) and in-situ optical inspection.
  - Testing equipment suitable for cyclic fatigue tests. HCF (High Cycle Fatigue) testing will be considered an add-on.
  - Tools and methods for destructive and non-destructive inspection.
  - Tools and methods for in-situ contact-less multi-axial strain measurement by digital image correlation.
  - The applicant must demonstrate experience on pre-treatment procedure of the Titanium surface before bonding in order to ensure a long term stability under exposed conditions (hot/wet), etc.

III. Automated injection RTM system process based in innovative sensor technologies in a low cost smart manufacturing tooling prototype and any tooling involved in the manufacture or the validation of the structure

Type of action (RIA or IA)	IA		
Programme Area	LPA		
Joint Technical Programme (JTP) Ref.	WP 1.4		
Indicative Funding Topic Value (in k€)	1000 k€		
Duration of the action (in Months)	24 months	**Indicative Start Date**[3]	Q1 2017

Identification	Title
JTI-CS2-2016-CFP03-LPA-01-14	**Automated injection RTM system process based in innovative sensor technologies in a low cost smart manufacturing tooling prototype and any tooling involved in the manufacture or the validation of the structure**

Short description (3 lines)

The aim is to develop, design and manufacture, all the prototype subcomponent manufacturing and trial tooling involved in the development of the HLFC leading edge.The development of this tooling should be innovative in order to implement the best performances in:

- Low Cost/ Natural Materials employed in the tooling manufactured
- Eco-design for of the tooling manufactured
- Energy savings during the manufacture processes of the future parts, for example by implementation of a more efficient heating system
- Manufacturing processes simplification in order to reduce to improve the repetitiveness of the process
- Production time savings to reduce the cost and production lead times

Always ensuring that each one of the single parts manufactured with the prototype tooling fit with the Aeronautical quality standards.

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

1. Background

The objective of this topic is to design and manufacture the RTM tooling to manufacture a leading edge that includes a HLFC system. The scope of the proposal includes the manufacturing of the RTM mould and any other tooling needed to manufacture the prototype or to validate the process or the structure.

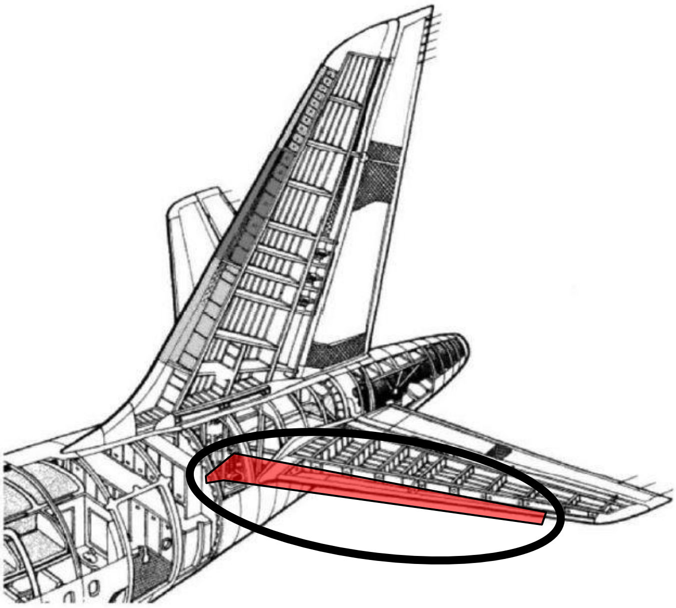


Figure 1: Example of structures of interest,

in this particular case the structure will be the LE of the Horizontal Tail Plane (HTP)

2. Scope of work

The conceptual and the preliminary design will be provided to the Partner by the Core Partner (CoP). In general, the conceptual design of every component will be defined within the frame of the LPA by one of the Core Partner (CoP) while the detailed design and manufacturing will be done by the Partner with the concurrence of the CoP.

The final requirements and features needed for the Prototype Manufacturing tooling and any other tooling will be provided by CoP in accordance with the Airframer at the beginning of the project.

The manufacturing tooling should include:

- A self-regulating temperature system with embedded and advanced sensors to monitor the temperature at all times
- Reduce overall energy consumption by optimizing the cycle and the heating strategy.
- Surface Quality IAW the standards of the Aeronautic Industry.
- Manufactured employing low cost materials.
- Since the part might include metallic components, the tooling should take into account the different CTE that the part might present.

- The tool will include several independent modules which should be designed to allow their extraction and ensure a secure demoulding process.
- Any tooling needed for the defined manufacturing process apart from the RTM tooling.
- Any tooling need to validate the defined process or to validate the materials defined.

The final objective of this topic is to manufacture the needed tooling to manufacture the HTP Leading edge structure modified to include a HLFC system, employing liquid resin injection processes, in particular RTM to produce the mentioned part. The resulting structure shall comply with the actual regulation of the aerospace sector, in particular regarding geometrical tolerances and defects.

In order to provide a reliable and repetitive process, studies regarding the possibility to automate both the manufacturing and positioning of the perform (dry fiber stacking after a forming and consolidation process) and also the injection process would be desirable and valued. This may include the initial design of some kind of robot or automatic system to perform the task.

The CoP will support the Partner with the following tasks:

- Concurrent engineering with the CoP to reach the detail design level,
- Tradeoff for material selection, process automatization, heating and thermal control systems and integration of different materials,
- Defining the manufacturing process for the tooling,
- Manufacture of the tooling,
- Validation process according with aeronautical standards,
- Delivery of the prototype tooling to the CoP facilities.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Tradeoffs report: – Materials – Systems – Integration	Report	To+9
D2	Manufacturing process definition	Report	To+12
D3	Manufacturing tooling report	Report	To+18
D4	Manufacturing and validation tooling	Report	To+21
D5	Final report: Conclusions and lesson learned	Report	To+24

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Material tradeoffs	Report	To+9
M2	Manufacturing process defined	Report	To+12
M3	Prototype tooling manufactured	Hardware	To+18
M4	Prototype tooling validated	Report	To+21
M5	Prototype tooling delivered	Delivery	To+22

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

- Experience in design and manufacturing of manufacturing tooling for structures in conventional composite materials and innovative metallic components (M).
- Design and analysis tools of the aeronautical industry
- Experience in management, coordination and development technological (Aeronautical) programs. (M).
- Proved experience in collaborating with reference aeronautical companies with industrial air vehicle developments.
- Participation in international R&T projects cooperating with industrial partners, institutions, technology centres, universities and OEMs (Original Equipment Manufacturer). (A)
- Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004). (M)
- Capacity to repair or modify "in-shop" the prototype manufacturing tooling for components due to manufacturing deviations. (A).
- Qualification as strategic supplier of manufacturing tooling on aeronautical elements. (A).
- Experience and know-how with tooling for OoA Technologies, RTM in particular
- Experience and know-how with tooling for manufacturing metallic components. (M)
- Into the eco design field, the Partner shall have the capability to monitor and decrease the use of hazardous substances regarding REACH regulation (M).
- The above mentioned requirements will be fixed in more details during the partner agreement phase-Negotiation Phase. This will also include the IP-process.

(M) – Mandatory; (A) – Appreciated

IV. <u>High Fidelity time-accurate CFD Simulations</u>

Type of action (RIA or IA)	RIA		
Programme Area	LPA Platform 1		
Joint Technical Programme (JTP) Ref.	WP1.5		
Indicative Funding Topic Value (in k€)	300 k€		
Duration of the action (in Months)	24 months	**Indicative Start Date**[4]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-LPA-01-15	**High Fidelity time-accurate CFD Simulations**
Short description (3 lines)	
The framework is given by applying pulsed air blowing with Zero Net Mas Flux (ZNMF) to control the flow separation at the engine/pylon junction. For this application the objective of the partner is to determine the optimal flow control actuation parameters. These parameters presume a deep insight into the partially unknown flow phenomena of interacting shear layers and vortices to be obtained with high fidelity time-accurate numerical simulations for provided relevant configurations and under relevant conditions.	

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

1. Background

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

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

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

To remedy this problem Active Flow Control (AFC) based on pulsed air blowing with Zero Net Mass Flux (ZNMF) is applied at the engine-wing junction either at wing leading edge or at the engine pylon. The flow control actuators use a piezoelectric-based transducer to generate air jets. These air jets interact with the outer flow to alleviate or suppress flow separation downstream. It seems obvious to design the actuator hardware a clear view must be obtained on the dedicated flow phenomena. These are characterized by the actuator jets driven by the actuation parameters and the interaction of the jets with the outer flow being crucial for the effectiveness of flow separation reduction. The necessary insights are to be given by this topic based on high-fidelity numerical simulations.

2. Scope of work

The scope is to perform high-fidelity numerical simulations that help to understand the underlying flow phenomena and to deliver the aerodynamically optimal actuation parameters to the hardware developers.

As input, the existing consortium will provide a geometry configuration consisting of the fuselage, wing, slats/flaps, engine-pylon and through-flow nacelle (TFN) to the partner. The geometry is in line with a geometry tested in a later wind tunnel test. Similarly, the wind tunnel test conditions like the Reynolds number (>6 Mio with respect to the mean aerodynamic chord of the wing), Mach number (>0.15) and initial flow control actuation parameters will be given to the partner.

The partner creates the computational grids and carries out the necessary grid convergence studies with and without flow control. After finalizing the numerical setup incl. turbulence models, time integration etc. the partner will carry out a parameter variation within time-accurate simulations. Please note that actuation frequencies are up to 1 kHz (in special cases up to 2 kHz) so the applicant should avail of the necessary high performance computing resources. Parameter variation comprehends actuator arrangement (single-lane or multi-grid), actuator position, actuation frequency, actuation jet velocities and actuation angles.

The expected output is to deliver the set of optimal parameters to enable the design of the necessary hardware for giving the physical proof of concept in a wind tunnel test with a fully realistic configuration under realistic flow conditions.

The activities to be performed within the project shall include the following task table.

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T1	Grid generation and grid convergence studies	M3
T2	Analysis of three different actuation location incl. single lane and multigrid actuation	M12
T3	Analysis of momentum coefficient at preferred actuation location	M16
T4	Analysis of outlet geometry at preferred actuation location	M19
T5	Analysis of actuation frequency incl. amplitude modulation at preferred actuation location	M22
T6	Synthesis of recommended actuation parameters	M24

Task 1 Grid generation and grid convergence studies

The partner will receive the geometry configuration incl. the actuator geometry from the existing consortium. The geometry must be cleared of potential defects coming into play depending on the mesh generation method that is applied. The task includes the grid generation and grid convergence analysis for time resolved numerical simulations with and without flow control based on the provided initial actuation parameters. A final setup of the numerical method comprehends a selection of the turbulence model, boundary conditions etc. Afterwards the partner has to simulate the lift polar of the given configuration until the post-stall region.

Tasks 2- Task5: include the different studies that shall be performed to understand the impact of massless actuation on the flow in the relevant areas:

- **Analysis of three different actuation locations** incl. single lane and multigrid actuation**:** First, three different actuations shall be analyzed in order to define the most appropriate location for actuator momentum, velocity and frequency variation. Single lane and multigrid actuation should be covered.
- **Analysis of momentum coefficient at preferred actuation location:** Second, different actuator parameters shall be varied in order to analyze their impact on the flow phenomena and to understand the effect of changing parameters.
- **Analysis of actuation frequency incl. amplitude modulation at preferred actuation location:** Third, beside the change of the frequency, also a modulation (amplitude modulation at preferred actuation location) of the actuation signal shall be performed to analyze and understand the effect of modulation and to evaluate the potential of reduction of power consumption by changing the duty cycle of massless actuation

All these studies shall be performed, analyzed and discussed in order to prepare task 6.

In **Task 6**, based on the performed studies, synthesis shall be performed to recommend optimal actuator parameters for the development, installation and operation of the ZNMF actuators.

3. Major deliverables/ Milestones and schedule (estimate)

Major deliverables and milestones are summarized on the following tables:

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
Del.1	Report on numerical setup of AFC studies (incl. grid convergence etc.)	Report	M3
Del.2	Report on analysis of different actuation location	Report	M12
Del.3	Report on analysis of momentum coefficient	Report	M16
Del.4	Report on analysis of outlet geometry	Report	M19
Del.5	Report on analysis of actuation frequency incl. amplitude modulation	Report	M22
Del.6	Synthesis of recommended actuation parameters	Report	M24

Milestones		
Ref. No.	***Title – Description***	***Due Date***
M1	Mesh available and converged	M3
M2	CFD data available for synthesis	M22
M3	Synthesis of actuation parameters for Synthetic Jet Actuators	M24

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

- ✓ The applicant should have sound expertise in the area of unsteady CFD
- ✓ The applicant should have expertise in the area of active flow control
- ✓ The applicant should have HPC resources available or access to it
- ✓ The applicant should have Numerical tools for time resolved analysis available that can be used in highly parallelized computations suitable to realize the unsteady simulations with sufficient time resolution. Numerical solver should be able to run on the number of cores required for such a time-resolved simulation
- ✓ The applicant should have the necessary post-processing and visualization tools

V. Aerodynamic Isolated and Installed Methods for UHBR Adaptable Area Nozzles

Type of action (RIA or IA)	IA		
Programme Area	LPA Platform 1		
Joint Technical Programme (JTP) Ref.	WP1.5		
Indicative Funding Topic Value (in k€)	1100 k€		
Duration of the action (in Months)	36 months	Indicative Start Date[5]	Q1 2017

Identification	Title
JTI-CS2-2016-CFP03-LPA-01-16	Aerodynamic Isolated and Installed Methods for UHBR Adaptable Area Nozzles
Short description (3 lines)	
The aim of the project is to experimentally evaluate the performance and installation effects of Ultra High Bypass Ratio (UHBR) engines with Adaptable Area Nozzles (AAN). First, the effect on powerplant performance will be assessed for isolated configurations. The analysis of the isolated configuration will support the sizing of adaptable nozzles of different concepts. In a second step, the effect on powerplant performance will be assessed for installed configurations. The analysis of the installed configuration will show the effect of the mounting system and wing on the powerplant performance. The effect of the engine jet interactions with the airframe will be studied.	

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

1. Background

Reducing the fuel burn of commercial aircraft is a major factor in the development of aircraft engines. In the quest for reducing thrust specific fuel consumption, the mass flow rate of fuel burned per unit thrust of an aircraft engine, designs are trending towards higher bypass ratios. This increase in bypass ratio necessitates a decrease in the fan pressure ratio. Low fan pressure ratio engines may require variable flow-path geometry to account for an operating disparity between the fan flow conditions at different speeds. The fan and compressors in general, usually operate on an operating line or working line which is separated from the surge line by a safety margin, referred to as the surge margin. As the fan pressure ratio decreases, the surge margin becomes of greater concern due to the lower airflow velocities experienced by the fan. This problem can be combated by employing a variable nozzle to maintain the surge margin at a given operating condition. An Adaptable Area Nozzle (AAN) optimizes the area of the exhaust nozzle across the flight regime6.

Adapting the exhaust nozzle during the flight envelope reduces the risk of fan fluttering i.e. by opening the effective area during take-off, while at cruise flight conditions the nozzle exhaust area can be set to the optimized design point. The engine stability is improved; nevertheless, the powerplant performance might be affected by the change of the aero lines to allow for variable nozzle. Depending on the Adaptable Area Nozzle concept, the use of such technologies could lead to aerodynamic penalties which should be analysed. Understanding of aerodynamic effects back onto the engine performance especially effects which could be seen by the fan system will be essential to incorporating AAN's on the engine in future products.

The aim of the project is to evaluate the aerodynamic performance of Ultra High Bypass Ratio powerplants with Adaptable Area Nozzles. The analysis of a range of different AAN concepts (expected 2-3 types of AAN) will support the verification of methodology for the further development and sizing of AANs required to meet engine requirements. The second objective of the project is to assess the effect of the installation on the engine performance. The results will support validation of numerical methods for performance prediction. The analysis of the isolated and installed adaptable area nozzle concepts will allow:

- Development & verification of a methodology for AAN sizing and evaluation to TRL 4.
- A better understanding of the effect of AAN on powerplant performance.
- A performance prediction of different AAN concepts which can be compared against engine requirements.
- A better understanding of the effect of the wing installation on AAN powerplant performance.
- Assess the interaction of the engine jet with the mounting system and wing/high-lift devices.
- To develop a best practice guide for the evaluation of AAN installation effects on aerodynamic powerplant and wing performance.

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[6] Source: Krishnan, G., Perullo, C.A., Mavris, D., "An Assessment of Relative Technology Benefits of a Variable Pitch Fan and Variable Area Nozzle", 49th AIAA Joint Propulsion Conference, July 2013, San Jose California, USA.

The main tasks can be described as follows:

- Numerical evaluation of AAN concepts for scaling and Reynolds effects.
- Definition of model (including instrumentation) and test cases for isolated configurations.
- Definition of model (including instrumentation) and test cases for installed configurations.
- Manufacturing of wind tunnel models.
- Wind tunnel test development.
- Analysis of results.

2. Scope of work

Evaluation of UHBR engines with AAN and their installation effects.

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T1	Definition of models and test specifications for isolated and installed configurations	T0+6 months
T2	Construction of wind tunnel models	T0+18 months
T3	Wind tunnel testing	T0+28 months
T4	Analysis of results	T0+36 months

Task 1

Based on selected candidate models (provided by Rolls-Royce), an analysis of the candidates should be performed to extract Reynolds and scaling effects which should support the definition of the model to be tested. This task covers the analysis and definition of construction constrains for the manufacture of the model. The expected scaling range of the models is for the isolated case, models considered between 1:10 to 1:16 scaled, for the installed case to have scaling factors of 1:25.

- Reynolds effect evaluation
- Scaling effect evaluation
- Definition of instrumentation for measurements
- Definition of model construction constrains
- Model AAN Drawings
- Model Wing definition for installed cases – Assumed concept/definition to be supplied externally

Task 2

This task relates to the development of the models according to previous task results.

- Manufacturing of isolated models
- Instrumentation of models
- Adaptation of models for wing installation

Task 3

- Wind tunnel test campaign
- Testing of isolated AAN to analyse effect on powerplant performance
- Testing of installed AAN to extract installation effects

Task 4

The results should be post-processed and evaluated.

- Post-processing of data
- Detailed analysis of 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+1 months
D2	Definition of isolated and installed models for construction (Task 1)	Report, CAD drawings	T0+6 months
D3	Definition of test cases (Task1)	Report	T0+8 months
D4	Models available for wind tunnel tests (Task 2)	WTT Models	T0+18 months
D5	Wind tunnel test data	Data	T0+28 months
D6	Report of wind tunnel test results(Task 3+4)	Report, Data	T0+36 months

Milestones			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M1	Work plan agreed (D1)	Review	T0+1 months
M2	Model defintion for manufacturing (D2)	Review	T0+6 months
M3	Isolated models ready for tests (D4)	Review	T0+12 months
M4	Wind tunnel models (isolated and installed) manufactured (D4)	Review	T0+18 months
M5	Wind tunnel tests completed (D5)	Review	T0+28 months
M6	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 aerodynamics of engine nozzle jet flows. It is desirable that the Wind Tunnel facilities are capable of dual airflows, with a Mach number range from 0.1-0.9. The WT facilities should feature the required instrumentation for aerodynamic nozzle performance measurements, i.e. Pressure and Temperature Rakes, Thrust Balance, PIV, etc. The accuracy/repeatability for Cd and CV should meet industrial requirements. The expected scaling range of the models is for the isolated case, models considered between 1:10 to 1:16 scaled, for the installed case to have scaling factors of 1:25.

The applicant shall:

- substantiate technical knowledge in the domain of proposed tasks
- demonstrate experience in project participation, international cooperation, project and quality management
- show that knowledge is recognized in the scientific community

It would be necessary to have familiarity with the special skills:

- general aerodynamic CFD modelling and method development skills
- found experience in nozzle jet flows /jet flow-flap-interaction
- expertise in experimental methods for engine jet flows

VI. Windtunnel test for flow control at the engine/pylon with a representative aircraft configuration under fully realistic flow conditions

Type of action (RIA or IA)	RIA		
Programme Area	LPA		
Joint Technical Programme (JTP) Ref.	WP 1.5		
Indicative Funding Topic Value (in k€)	800 k€		
Duration of the action (in Months)	14 months	**Indicative Start Date**[7]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-LPA-01-17	**Windtunnel test for flow control at the engine/pylon with a representative aircraft configuration under fully realistic flow conditions**
Short description (3 lines)	
To properly demonstrate the effect of flow control at the engine/pylon wind tunnel tests using a realistic detailed 3D model configuration under fully realistic flow conditions in terms of Mach number and Reynolds number are crucial. The model configuration will comprise a classic and an UltraHighBypass Ratio (UHBR) Turbofan nacelle with a cut back of the slats in the region of the pylon/wing, enabling a later translation of the flight test results with classic engines to the UHBR configuration. The wind tunnel tests shall be done with and w/o flow control, using pulsed jets, synthetic jets and steady blowing.	

[7] 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, such of a VHBR engine, the integration under the wing of current conventional aircraft under development is already challenging but becomes even more when novel aircraft configurations are considered, featuring highly integrated UHBR engines.

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

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

To remedy this problem Active Flow Control (AFC) based on steady and pulsed air blowing with and w/o net mass flux is applied at the engine-wing junction either at wing leading edge or at the engine pylon.
To reach TRL3, realistic aerodynamic test conditions are required, accepting a simplified presentation of the flow control system (thus of the actuators, system installation).

The objective is to modify an existing wind tunnel model that is provided by the topic manager's company, integrate flow control actuators into the model and perform wind tunnel tests, including measurements and flow visualization.

All related expertise, experiences and tools expected from the partner are stated in section 5.

2. Scope of Work

The studies of the wind tunnel (WT) investigations have to include the following aspects:

- Modification of existing WT model so that important flow features are represented
- Installation of the different AFC systems into the WT model
- Installation of sensors (pressure, temperature) into the WT model
- WT Testing of AFC technologies for this application, including the use of 3D flow visualization
- Providing of the whole set of data and analysis of the data for actuator optimization

The following tasks are to be performed by the Partner:

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T1	Modification of the model, including the integration of the actuators (pulsed jets, synthetic jets and steady blowing)	M9
T2	WT/T for the different test scenarios (model and actuators)	M10
T3	Data analysis and delivery of the test report	M14

Task 1: Modification of the model, including the integration of the actuators (steady blowing, pulsed and synthetic jets)

An existing WT model (1:13.6) will be provided by the already existing consortium to the selected partner. This WT model shall be modified in order to enable the installation of AFC hardware and systems for the test of the actuators. In addition, the measurement and control hardware shall be integrated into the wind tunnel model. Actuator inserts will be also delivered from the existing consortium.

Computer Aided Design (CAD) drawings shall be provided to the CS2 LPA partners in order to ensure that space and installation constraints for AFC inserts and systems can be fully considered. The wind tunnel model is equipped with a V2500 nacelle (through flow nacelle). The geometrical data for a new UHBR nacelle and pylon will be delivered, whereas the manufacturing of the nacelle and pylon will be done by the partner.

In addition the wing has to be modified in such a way to accommodate the actuators and the needed pipes and wiring needed for the control and supply of the actuators. This includes also manufacturing of new slats with a specified cut back by the existing consortium.

In terms of AFC systems installations preference is clearly given to easily removable, interchangeable inserts for testing and comparing the three technology concepts of flow control with reduced effort. Design and installation of inserts will be supported by the CS2 LPA partners in order to be suitable for the AFC actuators that will be used for the investigation.

The selected applicant must account for two different positions of the actuator blowing slot, needed to study the influence of the actuator slot position on the effectiveness of the flow control.

Table 1: Matrix of model configurations and flow control settings

Configuration of the model / Flow control settings	V2500 nacelle	UHBR nacelle
w/o flow control (incl. variations of the nacelle strake position)	X	x
Pulsed jet actuators	X	X
Synthetic jet actuators	X	X
Steady blowing	X	X

Necessary measurement equipment (steady and unsteady pressure sensors, mini-tufts, oil flow visualization, surface streamlines visualization, balance measurements, deformation measurements, etc.) shall be provided, set-up and installed.

Task 2: Execution of the tests with different configurations of the nacelle and actuators

The wind tunnel test will be done with the different configurations, shown in Table1.

The test matrix will be delivered by the topic manager's company. The Ma number of the wind tunnel free stream has to be adjusted between 0.1 and 0.3 and the Re number must be higher than 6 Mio based on the Mean Aerodynamic Chord (MAC) of the model which is 0.3m and freestream conditions.

The test matrix will comprise a variation of the angle of attack, of the Ma number and of the velocities of the flow control jets. The Ma number of the jets has to be adjustable between Ma = 0.3 and 0.9.

The planned test will include measurements of the overall forces acting on the model (balance measurements), as well as pressure distributions on the wing surface. In addition the mass flow of the air supply for the flow control actuators will be measured, the pressure and temperature inside the ducting and the settling chamber of the actuators.

The second part of the wind tunnel campaign will consist of 3D flow visualization at the wing upper surface using particle image velocimetry (PIV) for a specified number of configurations. The PIV technique will be provided by the applicant. This data will be used for an enhanced understanding of the mechanism of interaction between the flow control jets and the surrounding flow.

Task 3: Data analysis and delivery of the test report

The data of the wind tunnel test are to be analysed and results to be delivered to the consortium. This analysis will include overall measurements (balance), pressure measurements on the wing surface and data about the flow control characteristics (mass flow, pressures, temperatures).

A second delivery will be the analysis of the flow visualization task, including 3D information of the flow downstream the actuators.

3. Major Deliverables/Milestones and Schedule (Estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Modified wind tunnel model	Report/ Hardware	M9
D2	Wind tunnel test report (excl. results from PIV measurements)	Report	M12
D3	Wind tunnel test report of PIV measurements	Report	M14

Milestones		
Ref. No.	***Title - Description***	***Due Date***
M1	PDR of wind tunnel model modifications	M3
M2	CDR of wind tunnel model modifications including the installation of measurement equipment.	M4
M3	TRR of wind tunnel model modifications	M8
M4	Wind tunnel test completed	M10

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

The applicant must have expertise in the area of wind tunnel model modification and model instrumentation. The applicant must have expertise in the area of wind tunnel testing, flow measurements, data post processing and flow visualization (tufts). The applicant must be able to prepare, conduct and evaluate PIV measurements.
The wind tunnel facility of the applicant must allow Reynolds number of over 6Mio with respect to free stream conditions and the mean aerodynamic chord of the wind tunnel model, which is 0.3m, and the wind tunnel facility must ensure a free stream Mach numbers of up to 0.3. Wind tunnel blockage defined by frontal area of the wind tunnel model compared to the wind tunnel cross section area shall not exceed 1%.
The applicant shall have a sound R&T background in testing and demonstration of flow control techniques in wind tunnel facilities suitable for models of the size mentioned above. The applicant must provide at least 20g/s air mass flow for the flow control systems while the pressure ratio between the actuator inlet compared to test section static pressure must be greater 8, including the needed system infrastructure to feed the actuators with the pressurized air flow. Modelling the suction mode of synthetic jet actuators requires a vacuum pump, which has to be provided by the applicant. This pump should be able to generate an air mass flow of at least 20g/s with a pressure ratio of 1/5 between the pressure in the actuator settling chamber compared to ambient pressure.

The wind tunnel facility shall be available during the testing period.

VII. High production rate composite Keel Beam feasibility

Type of action (RIA or IA)	IA		
Programme Area	LPA		
Joint Technical Programme (JTP) Ref.	WP 2.3.1.2		
Indicative Funding Topic Value (in k€)	600 k€		
Duration of the action (in Months)	24 months	Indicative Start Date[8]	Q4 2016

Identification	Title
JTI-CS2-2016-CFP03-LPA-02-08	High production rate composite Keel Beam feasibility
Short description (3 lines)	
The keel beam is a highly loaded structural element located in the lower centre fuselage. The aim of this call for partner is to conduct a feasibility study to propose a compromise between performance and cost taking into account manufacturing needs and constraints (low cost & high volume technology), through the use of a composite technology.	

[8] 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 2).

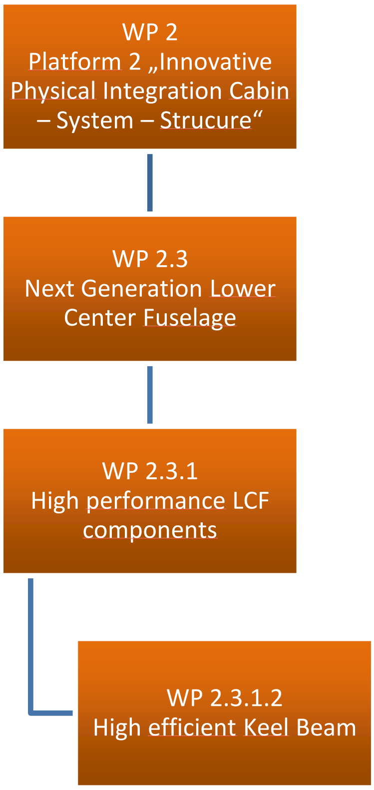


Figure 2

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

Within the context of Work Package 2.3, the main technical innovation is based on the development of a Body Landing Gear.

The project targets an implementation within a new short range aircraft development to be launched by Airbus.
As such, the applicants will have to be very innovative in order to propose 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 50 aircrafts a month**, with a good robustness, aiming at a very high ramp-up (150A/C the first year).

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

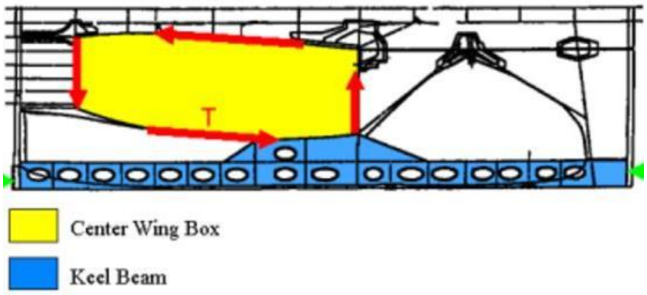


Figure 3: Keel-beam interfaces (A320 sketch)

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

Project objectives

This project aims at developing a **composite keel-beam** at an affordable cost for a short range aircraft such as A320.

The today reference for such a part is the A350 composite keel beam (A340 KB being different in terms of architecture and interfaces).
The concept relies in 4 panels assembly (see figure 5), manufactured with thermoset prepreg materials using well known technologies such as automated lay-up and autoclave curing cycle. The lower and upper covers have composite stringers and the internal ribs are bolted to the panels.

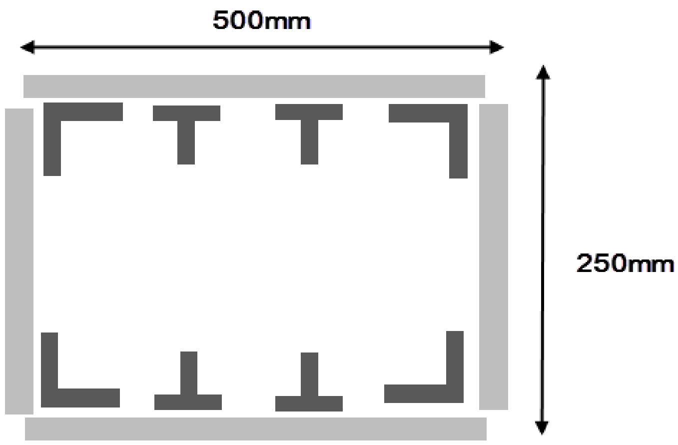


Figure 4: General cross-section assembly concept (rib not represented)

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 manufacture

and assembly. The results show that the price of the keel beam is very high, and not competitive versus metal.
In fact the process for these 4 panels, including rib integration, is **very 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.
If we want to take **full benefit of the composite properties** for the future aircraft development, we need to focus 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 composite material and the design associated. 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 architecture may also be changed in order to take full benefit of the technology and process choices (number and shape of the ribs, stiffening choice …) as long as the input envelops and interfaces are respected.

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.

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 50 aircrafts per month) with a **Design to Cost** philosophy.

The deliverable will be a report explaining the manufacturing route. RC savings expectations compared to the reference (to be further communicated by Airbus) will be presented.

At least one specimen trial should be manufactured: a small scale cross section assembly or the rib integration or any other demonstration judged relevant by the applicant.

Planning

The maturity level to reach at the end of those 2 years 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 + 3M
T 3	Concept phase	M0 +12M
T 4	Demonstration phase	M0 + 24M
T 5	Manufacturing route	M0 + 24M
T 6	Value and Risk analysis	M0 + 24M

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 1	**Detailed planning** for Engineering and Manufacturing activities with risks associated	Report	M0 + 3M
D 2	**TRL2 maturity**	Report	M0 + 12M
D 3	**Demonstration phase** Feasibility study, report	Report, CAT Parts	M0 + 24M
D 4	**Manufacturing route**	Report	M0 + 24M
D 5	**TRL3 maturity** Value and Risk analysis	Report	M0 + 24M

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

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

Mandatory skills:

- Knowledge of aeronautical environment
- Recognized skills in 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

VIII. Structural energy storage and power generation functionalities in multifunctional composite structures

Type of action (RIA or IA)	RIA		
Programme Area	LPA [Platform 2]		
Joint Technical Programme (JTP) Ref.	WP 2.1.2		
Indicative Funding Topic Value (in k€)	1130 k€		
Duration of the action (in Months)	36 months	**Indicative Start Date**[9]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-LPA-02-11	**Structural energy storage and power generation functionalities in multifunctional composite structures**
Short description (3 lines)	
Development of structural energy storage and power generation technologies in the frame of the multifunctional fuselage. The volume of energy storage needed is increasing with every new aircraft programme. Using the aircraft structure materials for those additional functions is a key contributor for reducing the weight and cost penalties and could be an enabler for new aircraft architectures.	

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

1. Background

The approach of the Innovative Physical Integration Cabin-System-Structure Platform 2 is to provide the frame for large-scale complex demonstration, as a segmented feature demonstrator or at full size for validation and testing on the ground. The target is to validate high potential combinations of airframe structures using advanced materials and applying innovative design principles in combination with the most advanced electrical system architecture in combination with the next generation cabin. The driver of this approach is to attain up to a double digit fuel burn reduction by substantially reducing the use of secondary energy, applying low weight systems and system architecture/integration and to be able to cash in weight potentials in the structural design of the fuselage and the connected airframe structure.

Platform 2 is organized along four work packages in which WP 2.1 is linked to the multi-functional fuselage demonstrator, see figure 1. This work package, 2.1.2, is in charge of defining and maturing multi-functional concepts and technologies.

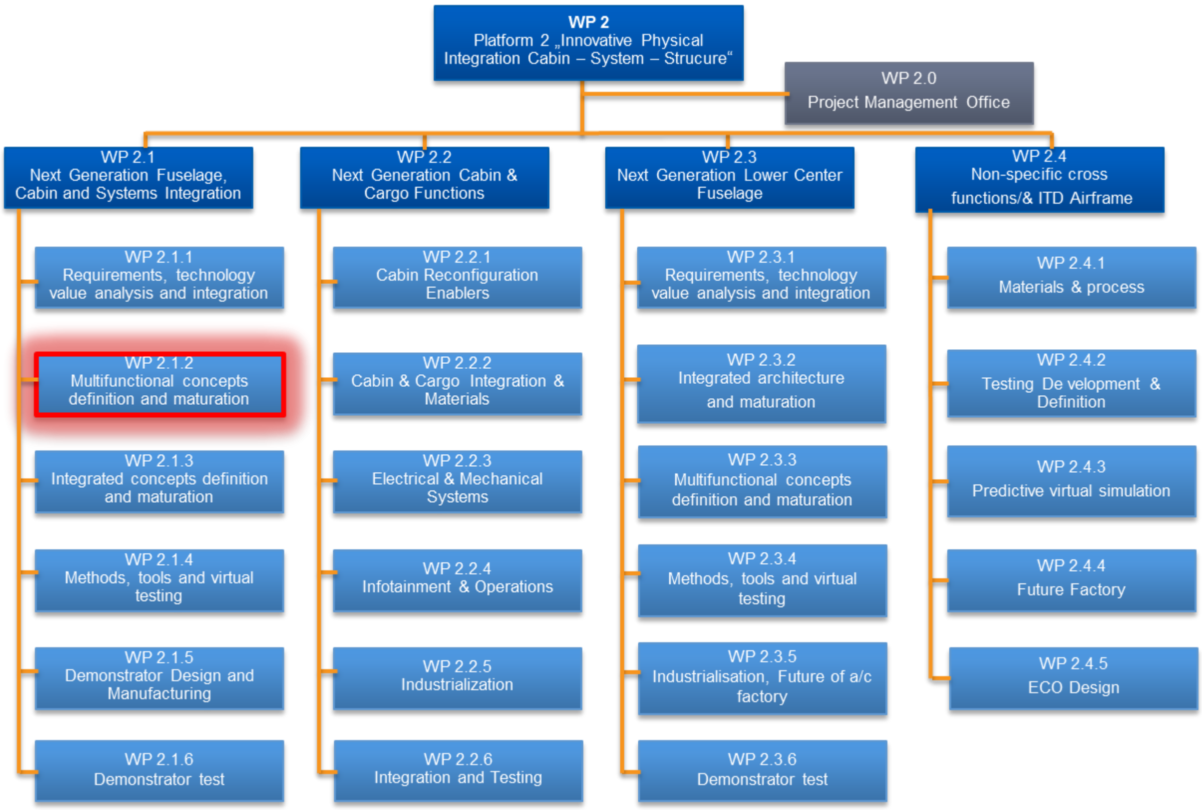


Figure 1 – LPA Platform 2 – "Innovative Physical Intergartion Cabin- System-Structure" Work BreakdownStruture

Civil aircraft tends to require increased electrical energy. The replacement of hydraulics by electronic systems, increased demands for communication and entertainment reinforce this trend. There is additionally a large interest to replace combustion energy within the propulsion system with electrical energy, which furthermore reinforces the estimated trend.

The future multi-functional fuselage approach will be a way to further optimize overall aircraft efficiency. Therefore we are looking for optimizing the electrical power storage by function integration. Structure could be part of the game playing both roles such as structural and systems functionalities.
This topic represents the pinnacle of structure-system integration and a true multi-functional structure that must be developed by ensuring maintaining structure load carrying capability. We expect to be able to use oversized structures in order to offer additional energy storage functionality, reducing the combined overall weight and cost impact.
This necessitates verification of energy storage capabilities of advanced material concepts in industrial environments and realistic structure operational considerations, the validation of energy input/output/conversion and transportation capabilities as part of the load carrying structure and, above all, to verify this with a net-positive life-cycle assessment

In that context, the project will be oriented on the development on an innovative composite material offering the possibility to store energy and to generate energy taking into account the material characteristics to sustain other expected properties that will be defined by the Topic Manager. There are already advances in research performed in recent years, generaly named "Composite batteries" (see an example in figure 2 here under) characterized by using chemically prepared carbon fibres as electrodes, and developing a solid polymere functioning as a solid electrolyte, thus providing structural properties comparable to traditional composites, with electrical energy storage capacity.

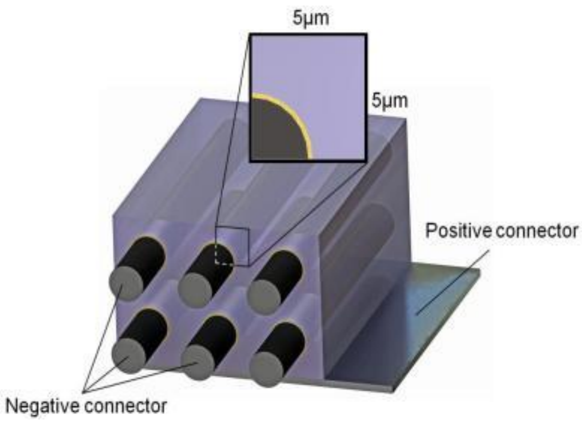


Figure 2- Composite battery-Lithium-ion battery in form of „Structural power composite", extract Elsevier Volume 101

First experiments of this technology took place around the year 2000 in Sweden. First realistic demonstrators of this type were built from 2004 in Scandinavia, and in the UK. The automotive industry, having efficient electrical cars as a goal, have shown interest and participated in some projects.

2. Scope of work

The project must be oriented on the development of a innovative composite material and/or structure elements that will act as battery capability and power generation with probabebly a combination of different technical solutions within same frame as for classical aircraft battery, such as delivery power generation at 24 voltages with ennergy transfer capability. The solution is not limited to the example shown in paragraph 1 figure 2.

The expected outcome is a real prototype of 2m² representing a typical fuselage structure with both fonctionalities, taking Topic Manager inputs defining the structural and system constraints that must sustain the composite Structure and System functionalities..

It is important that the primary function of the structure, load transfer, must under no circumstances be compromised by the addition of an additional functionality. Furthermore, conditions during structure part manufacturing, main component assembly and the final structure assembly are very different for large structural parts and assemblies than for system installation.

The expected technology solution must be delivered with some underlying data coming from simulation development for verification against Topic Manager requirements. The time until TRL2 - technology concept and application definition should then be used to verify adherence to key showstopper requirements experimentally. And through detailed simulation while the time to TRL4 - prototype validation in lab environment shall be used for completion of the fundamental test pyramid of developed solutions, storage and power generation technologies, which will be implemented on the prototype.

All within the time frame is detailed in figure 3, and followed by tables detailing tasks, deliverables and milestones.

Throughout the conduct of the project, the Topic Manager will review and steer the consortiums progress in bi-annual gate reviews according to the maturity criteria determined by the Large Passenger Aircraft WP2 criteria.

After demonstration of the solution capability, the Topic Manager will integrate it into new structure designs and system integration.

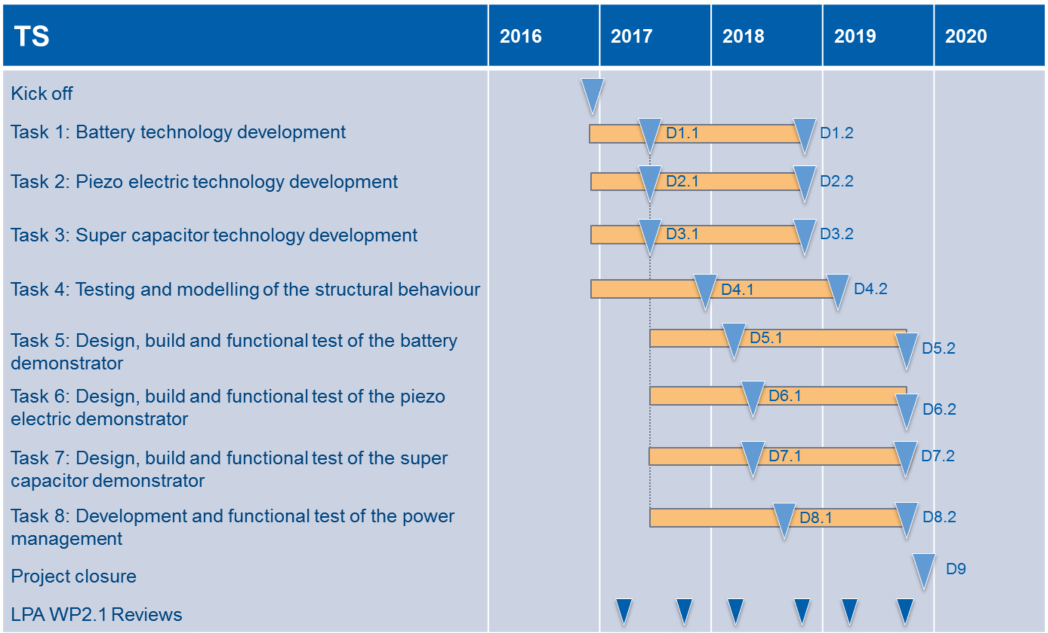


Figure 3 – Time scale of the expected works

Tasks		
Ref. No.	***Title – Description***	***Due Date***
1	Technology improvement of battery function; and adaption for use in aircraft; aircraft-adapted cathode, external power management, improved carbon fibres, external power management, manufacturing methods	T0 + 22
2	Technology improvement of power generation function: test of load spectrum range for efficient operation. Amplitude range to be determined. External power management, Manufacturing methods	T0 + 22
3	Technology improvement of structural super capacitor; determination of charging rates and discharging rate for reliable operation. External power management. Manufacturing mentods.	T0 + 22
4	Evaluation of structural behaviour, starting from coupon level, to element level, for battery function, for super capacitor and piezoelectric functions. Development of numerical model.	T0 + 26
5	Development and building of a basic aircraft demonstrator in form of cabin lining panel integrated structural battery. Load program of typical cabin interior electric loads.	T0 + 34
6	Development and building of a basic aircraft demonstrator in form of integration in skin in airframe stiffened panel, power management for charging battery	T0 + 34
7	Development and building of a basic aircraft demonstrator of structural super capacitor integrated in cross beam, power management for charging from battery	T0 + 34
8	Development and building of a power management to steer the integration of the three functions of the demonstrators	T0 + 34

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1.1	Concept description of battery composites incl. the basic demonstrator	Report	T0 + 6
D1.2	Evaluated battery composites development	Report	T0 + 22
D2.1	Concept description of power generation structural materials acting incl. the basic demonstrator	Report	T0 + 6
D2.2	Evaluated power generation development	Report	T0 + 22
D3.1	Concept description of structural super capacitor incl. the basic demonstrator	Report	T0 + 6
D3.2	Evaluated structural super capacitor development	Report	T0 + 22
D4.1	Coupons test results	Report	T0 + 12
D4.2	Structural behaviour of battery, piezo. comp, and of super capacitor	Report	T0 + 26
D5.1	Battery Composite physical demonstrator	Hardware	T0 + 15
D5.2	Battery Composite demonstrator summary incl. functional test report	Report	T0 + 34
D6.1	Power generation physical prototype	Hardware	T0 + 17
D6.2	Power generation prototype summary incl. functional test report	Report	T0 + 34
D7.1	Structural super capacitor physical demonstrator	Hardware	T0 + 17
D7.2	Structural super capacitor demonstrator summary incl. functional test report	Report	T0 + 34
D8.1	Power management for demonstrators	Hardware	T0 + 20
D8.2	Power management for demonstrators summary incl. functional test report	Report	T0 + 34
D9	Final report	Report	T0 + 36

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
1	Kick-off meeting		T0
2	LPA WP 2.1 review		T0 +3
3	LPA WP 2.1 review		T0 + 9
4	LPA WP 2.1 review		T0 + 15
5	LPA WP 2.1 review		T0 + 21
6	LPA WP 2.1 review		T0 + 27
7	LPA WP 2.1 review		T0 + 33
8	Closure review		T0 + 36

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

The applicants shall have strong theoretical and experimental background in mechanical behaviour of carbon fibre reinforced plastics as well as electro chemistry. In particular, the following skills are to be demonstrated:

- Structural testing and numerical simulation of carbon fibre reinforced plastics
- Experience in electro chemistry and electric energy storage
- Experience in reserach on composite batteries based on solid electrolyte
- Experience in research on piezo electric composites based on solid electrolyte
- Experience in structural super capacisors based on solid eletrolyte

The applicant must have:

- composite manufacturing and assembly capabilities,
- electrical installations means
- testing bench units
- Typical simulation tools and track record of using them

IX. Development of system components for automated cabin and cargo installation

Type of action (RIA or IA)	IA		
Programme Area	LPA [Platform 2]		
Joint Technical Programme (JTP) Ref.	WP 2.4.4		
Indicative Funding Topic Value (in k€)	1250 k€		
Duration of the action (in Months)	36 months	Indicative Start Date[10]	Q1 2017

Identification	Title
JTI-CS2-2016-CFP03-LPA-02-12	**Development of system components for automated cabin and cargo installation**
Short description (3 lines)	
Development of modular system components and accomplishment of feasibility and validation tests with respect to use-cases of the cabin and cargo final assembly regarding flexible and mobile manipulators capable of human-robot collaboration.	

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

1. Background

A Future Aircraft Factory would be incomplete if essential automation technologies were not considered. In order to reach a true TRL 6 maturity level in disruptive concept architecture like the one developed here, manufacturability needs to be regarded as important criteria in the validation process. Although the integrated pre-production tests will be conducted in WP 2.4.4, the first step will be to develop specific technology bricks, and this is precisely the objective of this work package.

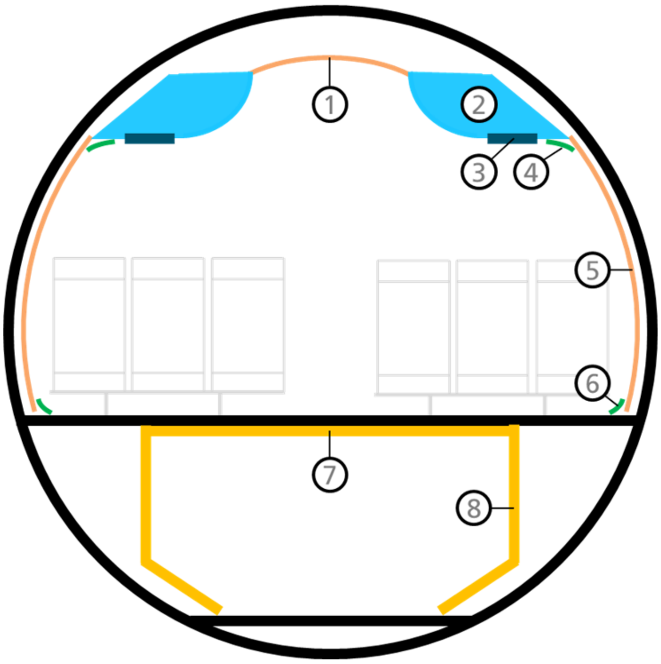
Assembly of aircrafts including system integration, cabin and cargo installation as well as testing nowadays is still mainly done manually, which is also true for supporting activities like logistics. Many of these activities today are in non-ergonomic conditions, process chains are very complex and not sufficiently transparent.

In this context automation of logistics processes, delivery of aircraft parts, e.g. to the assembly stations, coexistence of human and mobile robots during installation and fully automated processes for part, system, cabin and cargo installation shall be investigated. This shall also integrate possibilities to optimize process chains and ensure transparency of the current assembly status at all times.

The focus in this workpackage is the development and evaluation of system components for automated linings and hatracks installation in cabin and cargo in presence of human work force (see figure 1).

There are challenges in many perspectives, like for example the need of mobile autonomous automation systems through aircraft doors and the limited access inside the aircraft (see figure 2). The automation systems also have to be very flexible and shall perform different operations at different locations, in order to minimize the amount of specialized systems and to reach a high utilization rate. Another challenge is the weight limit of automation systems to be able to work inside the aircraft, e.g. on the cabin or cargo floor (see figure 2).

Such automation systems would be a leap forward with regard to lead time, recurring costs and also flexibility and transparency.

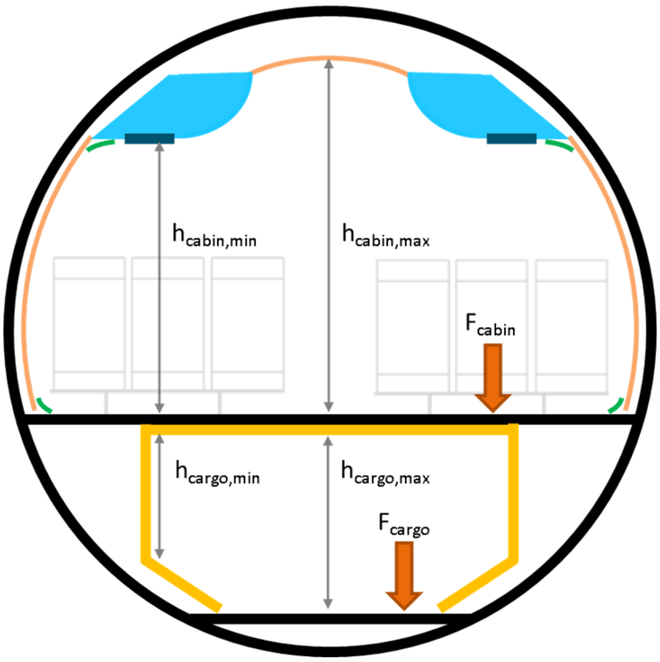


Cabin Components: | **Weights:**

Cabin Components:	Weights:
1. Ceiling	3,2 kg
2. Hatrack	19 – 26,5 kg
3. Passenger Service Unit	tbd.
4. Lightcover	tbd.
5. Sidewall	tbd.
6. Dado Panel	tbd.
• Door	tbd.
• Doorframe lining	tbd.

Cargo Components:	Weights:
7. Ceiling	tbd.
8. Sidewall	tbd.

Figure 1: Cabin and Cargo Linings & Hatrack



Cabin height:

- Minimum cabin height $h_{cabin,min}$ = 1598 mm
- Maximum cabin height $h_{cabin,max}$ = 2164 mm

Cargo height :

- Minimum cargo height $h_{cargo,min}$ = 797 mm
- Maximum cargo height $h_{cargo,max}$ = 1243 mm

Cabin & Cargo floor:

- Bending strength on floor
  - Normal load B_{normal} = 3530 N/ft²
  - Plastic deformation B_{deform} = 5290 N/ft²
- Compressive strength on floor
  - Normal load F_{normal} = 2 N/mm²
  - Plastic deformation F_{deform} = 3 N/mm²

Figure 2: Parameters in Cabin and Cargo

2. Scope of work

The main scope in this project is the conceptual design, the elaboration and the realization of a test setup in lab-scale for automated assembly tasks of cabin and cargo components in final assembly line. The applicant is expected to show feasibility and functionality of its developed test rig at shop floor of the topic manager. The test setup will concentrate on two example processes as described in WP 2 showing in parallel running assembly processes of at least two units. The topic manager company will support the applicant with information concerning the global concept for final assembly line, the structure of interfaces and the geometry of example parts for demonstration. Work packages and tasks to be executed ar listed as shown in the table below.

<table>
<tr><th colspan="3">Tasks</th></tr>
<tr><th>Ref. No.</th><th>Title - Description</th><th>Due Date</th></tr>
<tr><td>WP 1</td><td>Design and selection of versatile production concepts for all components of cabin and cargo final assembly listed in figure 1, except the door
▪ Analysis of automation potentials for cabin and cargo assembly with respect to the system to be developed in WP 2
▪ Conceptual design of working environments also regarding coexistence of human and mobile robots including safety solutions
▪ Mobilization and navigation of automated guided assembly systems
▪ Design of interfaces under consideration of requirements set by the A/C manufacturer and the Topic manager regarding data transfer
▪ Work out guidelines for design for automation (regarding process, part design, logistics, interfaces, eg.)
▪ Assessment of results together with the A/C manufacturer and the Topic manager</td><td>t_0 +24</td></tr>
<tr><td>WP 2</td><td>Feasibility and validation concepts for mobile system and automation components using two examples of cabin assembly tasks connected to coexistence applications. One of the examples is the sidewall lining, the second example has to be selected together with the A/C manufacturer and the Topic manager.
▪ Design of appropriate test setups on lab-scale
▪ Final specifications for design for automation
▪ Supply and setup of test rigs on lab-scale at facilities of the Topic manager
▪ Functional testing of automation components at facilities of the Topic manager</td><td>t_0 +30</td></tr>
<tr><td>WP 3</td><td>Selection of final automation components as contribution to a global future final assembly line concept
▪ Evaluation of automation technologies in lab-scale
▪ Final specifications for mobile coexistence systems</td><td>t_0 +36</td></tr>
</table>

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 1.1	Preliminary guidelines for design for automation	Report	t_0 + 6
D 1.2	Evaluation matrix of concepts for cabin and cargo installation	Report	t_0 +12
D 1.3	Results of assessment	Report and visualization	t_0 +24
D 2.1	Final specifications for design for automation	Report	t_0 +15
D 2.2	Elaborated design of test setup	CAD data (general exchange format e.g. STEP)	t_0 +18
D 2.3	Test rigs for cabin and cargo assembly	Test rig including all automation components like robots, mobile units, end-effectors and programs	t_0 +21
D 3.1	Final specifications for mobile coexistence systems	Report	t_0 +30
D 3.2	Final evaluation of automation technologies	Report	t_0 +33

Milestones			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M 1.1	Design and selection of versatile production concepts completed	Report	t_0 +24
M 2.1	Test rigs for cabin lining assembly tasks available and ready for functional testing	Test rig including all automation components like robots, mobile units, end-effectors and programs	t_0 +24
M 2.2	Feasibility and validation tests completed	Report, demonstration and video	t_0 +30
M 3.1	Final evaluation completed	Report	t_0 +36

	Year 1				Year 2				Year 3			
Activity *months → t_0*	+3	+6	+9	+12	+15	+18	+21	+24	+27	+30	+33	+36
Design and selection of versatile production concepts for cabin and cargo final assembly		D		D				M D				
Feasibility and validation of mobile concepts and automation components using two examples of cabin lining assembly tasks connected to coexistence applications					D	D	D	M		M		
Selection of final automation components as contribution to a global future final assembly line concept										D	D	M
Reporting Periods	*12 months →*				*12 months →*				*12 months →*			

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

The Applicant shall be a worldwide operating and leading expert in the development, realization and supply of automation systems possessing additionally the skills and capacities necessary for the implementation of an innovative project within the aerospace industry.

- Capabilities in development, realization and supply of flexible automation solutions
- Capabilities in development, realization and supply of flexible jigs, endeffektors and automation equipment
- Knowledge in intelligent logistics concepts for automated material handling and transportation
- Capabilities in automated guided mobile robotics, “pick and place” equipment and positioning systems
- Capabilities in industrial coexistence of human and mobile robot systems embedded safety and ergonomic solutions
- Experience and knowledge in design for automation
- Experience in the field of final assembly line

X. Design For Automated Installation Of Linings And Hatracks In Cabin And Cargo

Type of action (RIA or IA)	IA		
Programme Area	LPA [Platform 2]		
Joint Technical Programme (JTP) Ref.	WP 2.4.4		
Indicative Funding Topic Value (in k€)	750 k€		
Duration of the action (in Months)	36 months	**Indicative Start Date**[11]	Q1 2017

Identification	Title
JTI-CS2-2016-CFP03-LPA-02-13	**Design for automated installation of linings and hatracks in cabin and cargo**
Short description (3 lines)	
Design of interior parts and joining elements (brackets) must be suitable for automated processing. This work package aims at the development of such a design for linings, hatracks and corresponding bracket systems.	

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

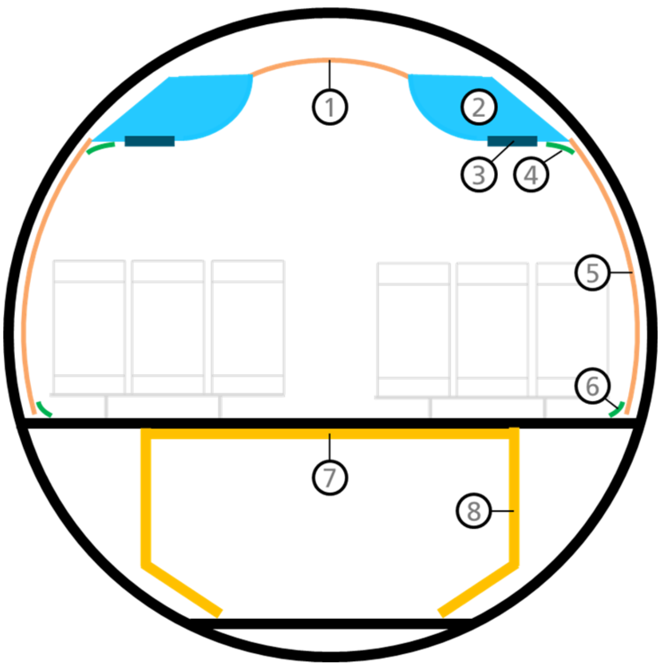
1. Background

A Future Aircraft Factory would be incomplete if essential automation technologies were not considered. In order to reach a true TRL 6 maturity level in disruptive concept architecture like the one developed here, manufacturability needs to be regarded as important criteria in the validation process. Although the integrated pre-production tests will be conducted in WP 2.4.4, the first step will be to develop specific technology bricks, and this is precisely the objective of this work package.

Assembly of aircrafts including system integration, cabin and cargo installation as well as testing nowadays is still mainly done manually, which is also true for supporting activities like logistics. Many of these activities today are in non-ergonomic conditions, process chains are very complex and not sufficiently transparent.

Based on capabilities of the latest generation of robots, sensors and control units, already a lot of parts in the Cabin and Cargo areas could be assembled automatically. In near future the automation capabilities will even rise significantly. However, as a prerequiste the design of interior parts and joining elements (brackets) must be suitable for automated processing. This workpackage aims at the development of such a design for linings, hatracks and corresponding bracket systems.

Such design for automation would be a leap forward with regard to lead time, recurring costs, flexibility and transparency.



Cabin Components:	Weights:
1. Ceiling	3,2 kg
2. Hatrack	19 – 26,5 kg
3. Passenger Service Unit	tbd.
4. Lightcover	tbd.
5. Sidewall	tbd.
6. Dado Panel	tbd.
• Door	tbd.
• Doorframe lining	tbd.

Cargo Components:	Weights:
7. Ceiling	tbd.
8. Sidewall	tbd.

Figure 1: Cabin and Cargo Linings & Hatrack

2. Scope of work

The main scope in this project is to develop cabin and cargo interior parts and joining elements optimized for automated assembly. For this reason, the applicant is expected to analyse the deviating requirements of an automated process requires in comparison with a manuel process. During this procedure, the applicant needs to work in close collaboration with the topic manager. On this basis the applicant is expected to develop and manufacture innovative solutions to enable flexible and productive automated assembly processes. Work packages and tasks to be executed ar listed as shown in the table below.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
WP 1	Investigations on cabin and cargo interior parts and joining elements for automated processing ▪ Analysis of redesign potentials for parts in Cabin and Cargo and work out guidelines for design for automation for the following three use-cases: ▪ Lining ▪ Hatrack ▪ Brackets ▪ Conceptual redesign for automation for all three use-cases ▪ Simulation of working process environments with redesigned parts also regarding human-robot collaborating (HRC) systems for all three use-cases ▪ Assessment of results together with the A/C manufacturer and the topic manager company.	t_0 +15
WP 2	Development and manufacturing of cabin and cargo interior parts and joining elements with respect to future aircraft concepts and relevant stipulations and general requirements for cabin and cargo ▪ Development of optimized cabin and cargo interior parts and joining elements for automated assembly ▪ Consideration of disassembly requirements ▪ Manufacturing of redesigned parts ▪ Iterative improvement and elaboration of redesigned parts through testing for all three use-cases	t_0 +30

Tasks		
Ref. No.	***Title - Description***	***Due Date***
WP 3	Functional testing and evaluation of cabin and cargo interior parts and joining elements in automated environment ▪ Final functional testing of parts with existing automation technologies of the topic manager ▪ Assessment of redesigned parts in automated environment ▪ Evaluation of results by the A/C manufacturer and the topic manager company	t_0 +36

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 1.1	Preliminary guidelines for design for automation	Report	t_0 +6
D 1.2	Simulation of working process environments for all three use-cases	Report and visualization	t_0 +9
D 1.3	Results of assessment	Report	t_0 +15
D 2.1	First redesigned parts for functional testing	Interior parts and joining elements as well as corresponding CAD data (general exchange format e.g. STEP)	t_0 +18
D 2.2	Final interior parts and joining elements for a fully equipped cabin and cargo demonstrator with a length of 3 side wall linings	Interior parts and joining elements as well as corresponding CAD data (general exchange format e.g. STEP)	t_0 +30
D 3.1	First test results	Report	t_0 +24
D 3.2	Final Evaluation of redesigned parts	Report	t_0 +33

Milestones			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M 1.1	Investigation on cabin and cargo interior parts and joining elements completed	Report	t_0 +15
M 2.1	First redesigned parts for functional testing available	Interior parts and joining elements	t_0 +18
M 2.2	Final designed parts available	Interior parts and joining elements	t_0 +30
M 3.1	Evaluation and tests completed	Report	t_0 +36

	Year 1				Year 2				Year 3			
Activity *months → t_0*	+3	+6	+9	+12	+15	+18	+21	+24	+27	+30	+33	+36
Investigations on cabin and cargo interior parts and joining elements for automated processing		D	D		M D							
Development and manufacturing of cabin and cargo interior parts and joining elements						M D				M D		
Functional testing and evaluation of cabin and cargo interior parts and joining elements in automated environment								D			D	M
Reporting Periods	*12 months →*				*12 months →*				*12 months →*			

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

The Applicant shall be a worldwide operating and leading expert in the development, realization and supply of fastening and innovative lining systems. Long term experience in aircraft cabin and cargo as well as consolidated knowledge of existing fastening and lining concepts have to be basis for the implementation of an innovative project within the aerospace industry.

The company shall be open minded about new materials and manufacturing processes and shall access a global engineering network.

Additional skills

- Capabilities in development, realization and supply of smart mechanical solutions
- Capabilities in development, realization and supply of intelligent, modular systems
- Knowledge in harmonized interfaces for automated material handling and transportation
- Experience and knowledge in design for automation
- Capabilities in alternative methods for cabin manufacturing

XI. Assembly Planning and Simulation of an Aircraft Final Assembly Line (FAL)

Type of action (RIA or IA)	IA		
Programme Area	LPA [Platform 2]		
Joint Technical Programme (JTP) Ref.	WP 2.4.4		
Indicative Funding Topic Value (in k€)	500 k€		
Duration of the action (in Months)	36 months	**Indicative Start Date**[12]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-LPA-02-14	**Assembly Planning and Simulation of an Aircraft Final Assembly Line (FAL)**
Short description (3 lines)	
The future assembly of interior components in the Cabin and Cargo areas will require a co-operation between automated systems and human work force. With the help of already available Virtual Reality and Augmented Reality-tools this project delivers a tool box for the related planning, control and quick adjustment of human-robot cooperation in the Cabin and Cargo Final Assembly.	

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

1. Background

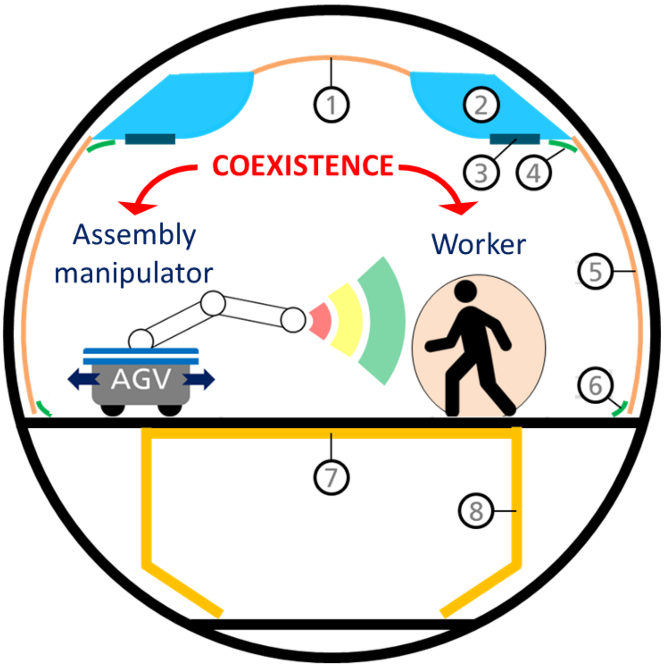
A Future Aircraft Factory would be incomplete if essential automation technologies were not considered. In order to reach a true TRL 6 maturity level in disruptive concept architecture like the one developed here, manufacturability needs to be regarded as important criteria in the validation process.

Assembly of aircrafts including system integration, cabin and cargo installation as well as testing nowadays is still mainly done manually, which is also true for supporting activities like logistics. Many of these activities today are in non-ergonomic conditions, process chains are very complex and not sufficiently transparent. The future assembly of interior components in the Cabin and Cargo areas will require a co-operation between automated systems and human work force.

However, there are narrow limitations in space and all processes need a certain degree of flexibility to ensure a smooth work flow even if sudden changes occur in the availability of resources. With the help of already available VR-tools and AR-tools this project delivers the basis for the related planning, control and quick adjustment of human-robot cooperation in the Cabin and Cargo 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 many perspectives, like for example the limited access inside the aircraft and the need of moving autonomous automation systems through aircraft doors.

Such assembly Planning and Simulation would be a leap forward with regard to lead time, recurring costs and also flexibility and transparency.



Cabin Components:	Weights:
1. Ceiling	3,2 kg
2. Hatrack	19 – 26,5 kg
3. Passenger Service Unit	tbd.
4. Lightcover	tbd.
5. Sidewall	
6. Dado Panel	
• Door	tbd.
• Doorframe lining	tbd.

Cargo Components:	Weights:
7. Ceiling	tbd.
8. Sidewall	tbd.

Figure 1: Cabin and Cargo assembly environment

2. Scope of work

The main scope of this project is to analyze, plan and optimize automated assembly tasks of cabin and cargo interior parts with a coexcistence of human workforce. The applicant is expected to set up a simulation environment based on virtual reality (VR) and augmented reality (AR) to display and evaluate alternative process scenarios. For this purpose, an important step beyond the state of technology is the implementation of process sequences for coexistence assembly tasks. Work packages and tasks to be executed ar listed as shown in the table below.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
WP 1	Assembly Planning by Virtual Reality (VR) ▪ Modelling of robot tasks and workmen activities including the main work cycles, resources, logistic requirements (e. g. pathways to storage areas/racks) with regard to an evaluation by economic/logistic and ergonomic criteria ▪ VR-driven Assembly Planning assistance for defining the operational procedures of the worker based on the modelling ▪ Simulation of coexistence (worker and robot) aircraft assembly processes ▪ Systemized evaluation of alternative assembly processes during the VR session with automated workflow guidance and documentation of the evaluation results ▪ Creation of the Augmented Reality visualization of worker tasks during the VR-Session	t_0 +27
WP 2	Evaluation of productivity potentials of coexistence aircraft assembly ▪ Identification of the current productivity of the actual aircraft assembly ▪ Identification of the achievable productivity of the future aircraft assembly	t_0 +30
WP 3	Visualization of assembly processes by Augmented Reality, done by robots, by worker or combined (including specific situations during the process, e.g. malfunction of the robot) ▪ Concept for visualizing the process sequences of worker, robots and for the coexistence assembly ▪ Visualization/monitoring of actual and relevant data about the robot's condition ▪ Visualization/monitoring of actual workload of the worker ▪ Visualization of maintenance information	t_0 +36
WP 4	Variants planning by Augmented Reality for enabling reactions on unpredicted situations at short notice ▪ Planning and visualization of general problem solving strategies (troubleshooting, maintenance, changes of process sequences) ▪ Planning and visualization considering the actual workload (capacity and competence of the worker)	t_0 +27

Tasks		
Ref. No.	***Title - Description***	***Due Date***
WP 5	Concept of a middleware to connect the different IT components ▪ Modular overall concept of a cross-linked Mixed Reality system ▪ Connection to CAD/PDM data ▪ Implementation of robot programs for visualization ▪ Connection of VR and AR to supply the mobile devices with data ▪ Connection of the AR-aided monitoring with the production control (interfaces) ▪ Concept of confirmation	t_0 +36

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 1.1	Simulation of assembly planning with VR and monitoring of robot/worker	Simulation* as videos and VR session together with the topic manager	t_0 +15
D 1.2	Evaluated alternative assembly processes during the VR session with automated workflow guidance and created AR visualization of worker tasks during the VR-Session	Report and simulation* as videos and VR session together with the topic manager	t_0 +24
D 2.1	Evaluated productivity potentials of coexistence assembly	Report	t_0 +30
D 3.1	First visualization of assembly processes by Augmented Reality	Video and simulation* as VR/AR session together with the topic manager	t_0 +24
D 3.2	Final visualization of assembly processes by Augmented Reality	Video and simulation* as VR/AR session together with the topic manager	t_0 +33
D 4.1	Final variants planning by AR	Report	t_0 +27
D 5.1	Final concept of a middleware	Report	t_0 +33

**including code and simulation environment*

Milestones			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M 1.1	Evaluation of alternative assembly processes completed	Report and simulation as videos and VR session together with the topic manager	t_0 +27
M 3.1	Visualization of assembly processes completed	Video and simulation as VR/AR session together with the topic manager	t_0 +36
M 5.1	Concepts of middleware completed	Report	t_0 +36

	Year 1				Year 2				Year 3			
Activity *months → t_0*	+3	+6	+9	+12	+15	+18	+21	+24	+27	+30	+33	+36
Assembly Planning by Virtual Reality (VR)					D				M D			
Evaluation of productivity potentials of coexistence aircraft assembly										D		
Visualization of assembly processes by Augmented Reality, done by robots, by worker or combined								D			D	M
Variants planning by Augmented Reality for enabling reactions on unpredicted situations at short notice									D			
Concept of a middleware to connect the different IT components											D	M
Reporting Periods	*12 months →*				*12 months →*				*12 months →*			

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

The applicant shall be an expert with strong scientific background as well as application focus in the field of aircraft production and assembly covering all main aspects of a production system.

- Interdisciplinary research and development team covering production and assembly, production management, planning, simulation, automation and technology competencies
- Simulation of work space and assembly operations in fuselage assembly environment using VR and AR equipment
- Assessment of alternative assembly strategies
- Experience in productivity management projects dealing with new overall concepts of large highly complex products manufacture and assembly
- Experience in measurement of worker and machine productivity
- Experience in the development of AR based worker information systems
- Experience in the integration of different IT systems
- Experience in the development of production control strategies
- Testing facilities for carrying out assembly operations as well as VR and AR simulations
- Knowledge and skills for process monitoring and in line quality assurance
- Experience in tool development for ergonomic human operations in narrow environments
- Competence and experience in 3D visualization of maintenance information
- Knowledge of industrial robot control, calibration, referencing and integration into an overall assembly environment

XII. Secured and performant wireless connection based on light (LiFi) for EFB, headset and other pilot connected devices

Type of action (RIA or IA)	IA		
Programme Area	LPA Platform 3		
Joint Technical Programme (JTP) Ref.	WP3.2		
Indicative Funding Topic Value (in k€)	1100 k€		
Duration of the action (in Months)	48 months	**Indicative Start Date**[13]	01 2017

Identification	**Title**
JTI-CS2-2016-CFP03-LPA-03-07	**Secured and performant wireless connection based on light (LiFi) for EFB, headset and other pilot connected devices**
Short description (3 lines)	
Design and development of ground tests prototypes for LiFi-enabled wireless communications means in aircraft for flight crew operations inside the cockpit, and associated cockpit integration impact analysis.	

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

1. Background

Current communication between the A/C and the pilot hand held or head worn devices (EFB, headset…) in the cockpit are currently based upon wired or WiFi connections. A wireless connection is much more efficient and brings comfort and mobility to the pilot. It is also an opportunity to introduce new services and functions by taking advantage of the flexiblity offered by mobile devices. Legacy wireless technologies such as WiFi have been introduced in the cockpit already to support tablet EFB. However, whereas WiFi is perfectly suitable for current usage, it will limit the introduction of further services due to bandwidth and data security limitations.

On one hand, so-called ISM bands used for WiFi and most available wireless technologies are saturated, which limits achievable performance and quality of service. On the other hand they are susceptible to jamming or intended interferences which limit their usage for communication from a mobile device to avionics, or for safety-critical functions. In addition using WiFi for such applications would require a high level of data security, generating heavy and expensives procedures and means.LiFi, or more generally light-based wireless communications, differs from legacy RF wireless technologies because they use light as the medium. Besides offering interesting possibilities in terms of integration to lighting systems, it brings the additional benefits of being immune to usual RF emissions perturbations, increasing the available resource and associated performances as well limiting interferences. In addition, it brings perspectives in terms of data security in the context of the cockpit flight operations utilization, as the light signal will not leave the cockpit, preventing eavesdropping as well as attacks.Using light-based wireless communication in the cockpit will enable secured and reliable connection between the pilot controlled devices and the A/C which can pave the way to new services for Airlines.

2. Scope of work

The targeted applicant is intended to define, develop, and deliver a robust light communication (LiFi) capability for a number of passenger aircraft cockpit application, namely: flight crew headset, Tablet/PC connection to the Aircraft (Electronic Flight Bag type), Pilot worn Connected Device (bracelet or similar type). In addition, other applications may be studied and included in the scope of work if consistant with the initial targets.

The solution shall comply with the requirements (data rate, latency…) of the said applications, as well as robust communications regarding possible interferences (smoke) and the cockpit environment both in normal and abnormal conditions.

The integration of the communication capabilities into the applications's systems shall be studied, spanning different options such as a dongle, or a fully integrated solution. It will help determine which solution suits better each of the considered application. The solution may take the form of a unique solution that fits all identified applications, or be specific to each application.

For each application, a comprehensive analysis of the impact of the proposed solution versus legacy wireless technology will be provided, spanning at least the following items: power supply, co-

existence with identical or similar wireless technologies, management and configuration, form factor, security, MTBF, safety.
The airworthiness conformity impact shall be assessed
For each application, a specification of the proposed solution will be provided. The specification will cover the design of the solution as well as interfaces with the target application. It is expected that the partner is knowlegeable of LiFi environment and standards. The specifications of proposed solution shall be compliant with these standards such as IEEE 802.15.7 and 802.15.4r1.
For each application, a prototype or proof of concept will be developped to illustrate and demonstrate the fundamental building blocks of the proposed solution, as well as expected performances.
The prototype will be integrated in an airframer cockpit simulator for tests campaign
Starting from a current state of the art at TRL3, The target is to achieve a TRL5 for the LiFi communication in the cockpit at the end of the project, and the applicant support is expected up to this end.
In addition, support for integration of the final management functions shall be provided to allow demonstration up to a potential flight test not part of the project.

The partner shall manage five major tasks within this CfP:

- LiFi connection integrated in the audio headset
- LiFi connection on a PC or on a tablet
- LiFi for connected devices
- Other applications to be identified
- Evaluation of impacts spanning all applications

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T1	Audio Headset	T0+30 months
T2	PC/Tablet connection	T0+24 months
T3	Connected devices	T0+48 months
T4	Identification of other applications	T0+48 months
T5	LiFi technology in aircraft evaluation	T0+48 months

<u>T1: Audio headset</u>

- Specification of audio headset function using LiFi capabilities:
    - Headset side
    - Aircraft side
- Analysis of possible integration solutions and selection of most promising one
- Development of prototype in near infra red spectrum and/ or visible light.
- Support integration & test in Airbus facilities
- Realization of a Proof of concept, prototyping

T2: PC/Tablet connection

- Specification of PC/Tablet connection to to aircraft using LiFi capabilities:
  - PC/Tablet side
  - Aircraft side
- Analysis of possible integration solutions and selection of most promising one
- Support integration & test in Airbus facilities
- Realization of a Proof of concept, prototyping

T3: Connected device

- Specification of device connected to aircraft using LiFi capabilities:
  - Connected device side
  - Aircraft side
- Analysis of possible integration solutions and selection of most promising one
- Support integration & test in Airbus facilities
- Realization of a Proof of concept, prototyping

T4: Identification of other applications

- Study of different possibilities for introducing additional LiFi wireless functions inside the cockpit
  - Replacing existing wired connections by wireless
  - New services/functions using wireless communication
- Selection of one or more applications amongst the identified application based on:
  - Consistence with other applications
  - Potential gain (new service, comfort, branding, weight, operational)
  - Feasibility
  - …
- For the selected applications
  - Specification of device connected to aircraft using LiFi capabilities:
  - Analysis of possible integration solutions and selection of most promising one
  - Support integration & test in Airbus facilities
  - Realization of a Proof of concept, prototyping

T5: LiFi technology in aircraft evaluation

- impact of introducing LiFI in the cockpit:
  - Integration in a cockpit, possible locations, required modifications
  - power supply management
  - interferences (light sources, obstacles…)
  - Co-existence with other wireless technology/LiFi emissions
  - Performances
  - MTBF
  - Security
- Multi users management

- Management of several applications using the same technology in the same environement (cockpit)
- Management of several users using the same application

- Standardisation monitoring and impact on LiFi introduction in aicrafts.
- Identification of impact on Airworthiness compliance

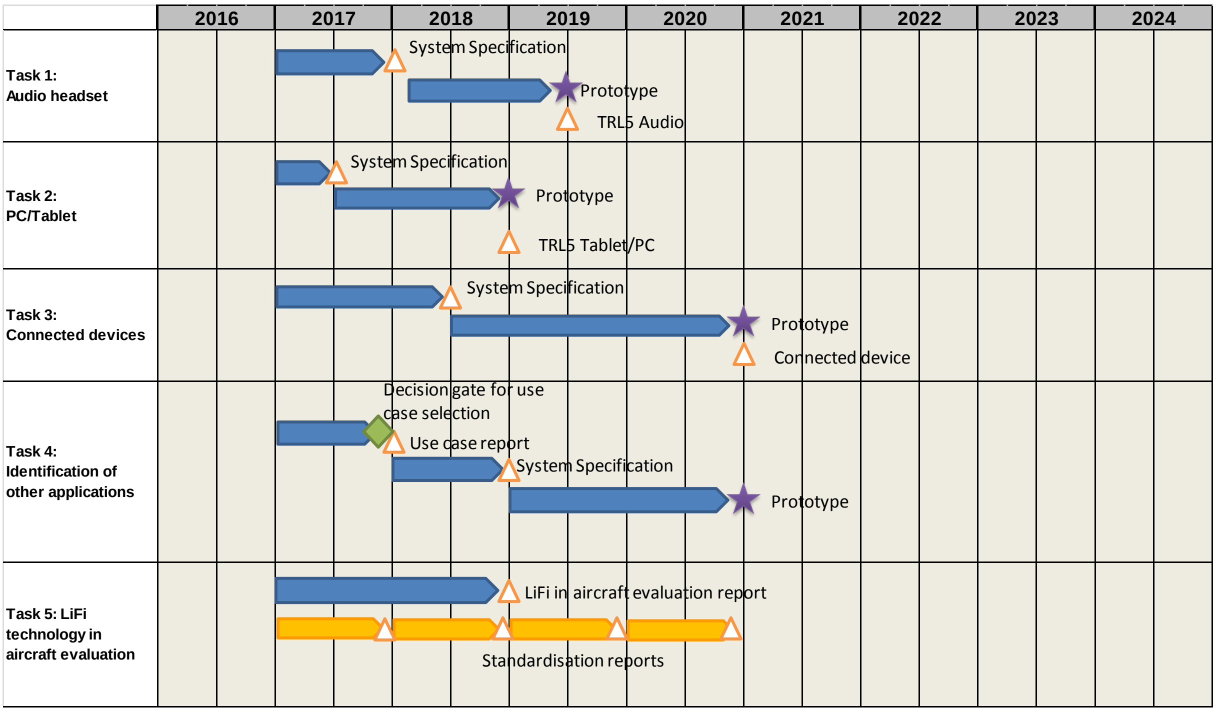
3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1_1	Specification of the audio headset with Lifi capabilities	R	T0+12 months
D1_2	Prototype/Proof of concept of the audio headset with Lifi capabilities	D	T0+30 months
D2_1	Specification of the PC/tablet with lifi capabilities	R	T0+6 months
D2_2	Prototype/Proof of the PC/tablet with lifi capabilities	D	T0+24 months
D3_1	Specification of the lifi connected device	R	T0+18 months
D3_2	Prototype/Proof of concept of the lifi connected device	D	T0+48 months
D4_1	Identification and evaluation of possible applications	R	T0+12 months
D4_2	Specification of selected applications	R	T0+24 months
D4_3	Prototype/Proof of concept of the selected applications	D	T0+48 months
D5_1	LiFi introduction evaluation report	R	T0+24 months
D5_2	Standardisation report	R	Annual report

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	TRL5 for PC/tablet with lifi capabilities	RM	T0+24 months
M2	TRL5 for audio headset with lifi capabilities	RM	T0+30 months
M3	TRL5 for connected devices	RM	To+48 months

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

Master Schedule



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

- Proven expertise in the LiFi technology
- Recognized actor in the IEEE 802.15.7 standardization working groups
- High expertise in the development of wireless components
- High expertise in the development of A/C headset
- Good knowledge in aircraft flight operations

IP management

The IP concerning the A/C integration solution must be owned jointly by Airbus and the applicant

2. Clean Sky 2 – Regional Aircraft IADP

I. Green Turboprop configuration - Natural Laminar Flow adaptive wing concept aerodynamic experimental validation (WTT2)

Type of action (RIA or IA)	IA		
Programme Area	REG		
Joint Technical Programme (JTP) Ref.	WP 2.1		
Indicative Funding Topic Value (in k€)	2250 k€		
Duration of the action (in Months)	30 months	**Indicative Start Date**[14]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-REG-01-02	**Green Turboprop configuration - Natural Laminar Flow adaptive wing concept aerodynamic experimental validation (WTT2)**
Short description (3 lines)	
Large scale wind tunnel experimental validation of a natural laminar flow flexible wing model (scale 1:3) integrating innovative morphing active devices (droop nose, morphing trailing edge, morphing winglet). WT Tests are planned in low speed and in "cruise conditions" to validate the relevant aerodynamic and aeroelastic performances at wing level.	

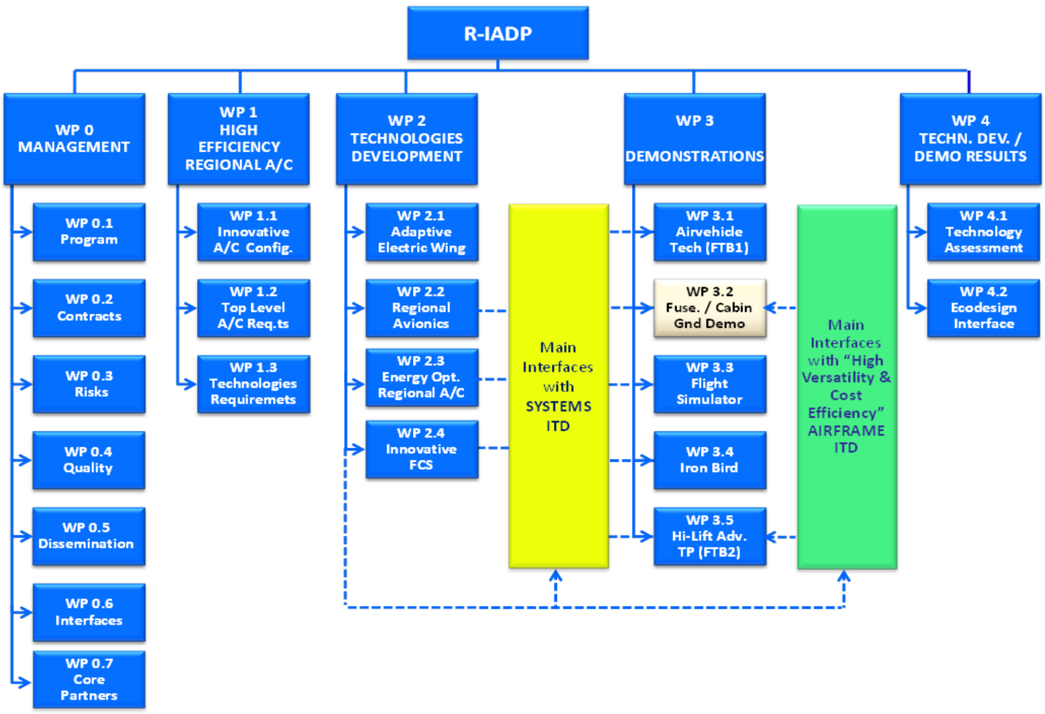
[14] The start date corresponds to actual start date with all legal documents in place.

1. Background

The purpose of the Regional Aircraft IADP is to bring the integration of technologies for regional aircraft to a further level of complexity and maturity than currently pursued in the current Clean Sky GRA. The global strategy is to integrate and validate, at aircraft level, advanced technologies for regional aircraft so as to drastically de-risk their integration on the following future products. Within the R-IADP the following large scale demonstrators are foreseen:

- Two Flying Test Beds (FTB), using modified existing regional turbo-prop aircraft with under-wing mounted engines, for demonstration campaigns; FTB#1 (Alenia Aermacchi) will mainly focus on the demonstration of technologies improving the cruise and climb performance, while FTB#2 (Airbus DS) will be oriented to test technologies for Regional A/C optimized for short point to point flights, connecting airports with short runways and, in general, towards more advanced high lift performances and more efficient configuration for climb and descending phases.
- Three large integrated Ground Demonstrators: full-scale fuselage and cabin (IADP), flight simulator and iron bird (IADP).

The Regional Aircraft -IADP WBS is below reported.



Focusing the attention activities planned in WP2.1, Innovative active High lift and load alleviation technologies are integrated with Natural Laminar Flow wing concepts:

- The aerodynamic design of a NLF outer wing for the TP airplane at cruise is done starting from a preliminary shape taking into account the specifications in term of flight conditions and aerodynamic performance desired. As final step of the NLF design, manufacturing requirements are defined for the regions with laminar flow, to avoid early transition due to geometrical defects. Different types of surface defaults are considered, such as surface roughness, steps, gaps or waviness.

- Taking advantage of the previous experience gained in the frame of Clean Sky – GRA ITD project by many of the involved partners, advanced Load Control & Alleviation technologies capable to improve the aircraft efficiency along the flight envelope and to mitigate the peak structural responses due to manoeuvre loads and gusts will be implanted in the NLF TP outer wing.
- Finally, the development of adaptive Winglet, morphing TE Flap and Droop nose will be managed from the conceptual design to experimental validations of full-scale models. Structural mechanics and material aspects will be investigated along with actuation systems, electronics and safety/reliability issues.

As part of the development plan, different technologies will be validated through large scale wind tunnel experimental validation of a natural laminar flow flexible wing model integrating innovative morphing active devices (droop nose, morphing trailing edge, morphing winglet).
Approaches and solutions finally developed will be scaled up to be further validated and finally implemented to the selected CS2 FTB#1 configuration.

2. Scope of work

Within the present project, a large scale natural laminar flow flexible wing model (scale 1:3) will be designed and manufactured integrating innovative morphing active devices (droop nose, morphing trailing edge, morphing winglet). WT Tests are planned in low speed and in "cruise conditions" to validate the relevant aerodynamic and aeroelastic performances at wing level. The facility in which to perform large scale wind tunnel tests is supplied by the REG IADP Member and will be provided as input for design activities.
In the following table, the different project tasks are reported:

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 1.1	Management	M30
Task 2.1	Wing WT Model Mechanical Design	M18
Task 2.2	Adaptive Devices and Instrumentation integration	M18
Task 2.3	Model Manufacturing and System Integration	M25
Task3.1	Ground Vibration Testing	M27
Task 3.2	WT testing support	M30

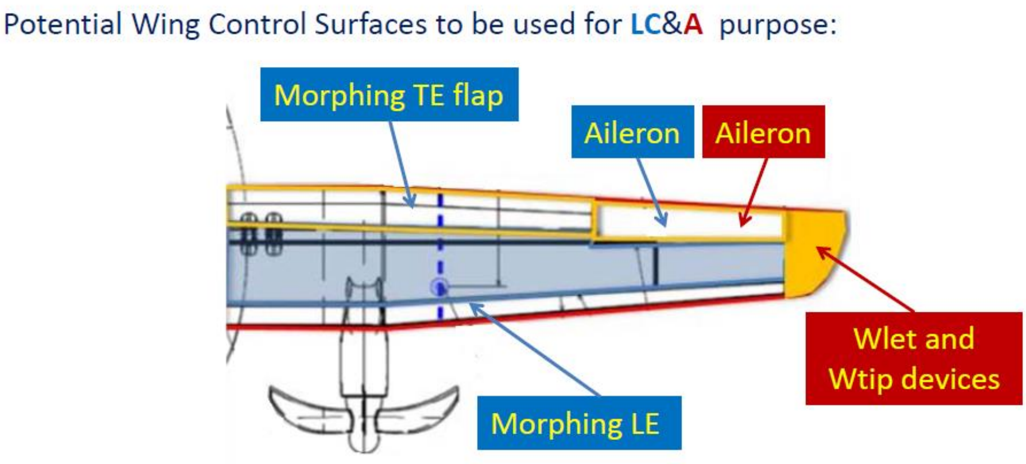
Task 1.1:Management

This task is responsible for the management of the project in order to ensure that all obligations are fully respected from a contractual and financial point of views. Taking into account the strong interaction between activities performed by REG IADP Core Partners and the present project, the present task will assure suitable communication between consortium, Topic Manager (REG IADP Leader) and JU.

Task 2.1: Wing WT Model Mechanical Design

Within the present task, based on inputs provided by REG IADP Leader (in terms of full-scale laminar wing geometry, aero-elastic wing model, LC&A devices, technical specification for WT testing), the Green Turboprop full-size aerodynamic / aero-elastic laminar wing equipped with LC&A morphing devices will be scaled down to the wing tunnel model size ensuring that the wing model deformation (the airframe torsional and bending deformation) be representative of the actual wing deformation at specified flow conditions.

The figure below shows the Green turboprop wing configuration evidencing the different adaptive wing concepts for LC&A purpose:



The expected Wind tunnel model scale is between 2 and 3 (span length = 5m-6m and average chord = 1m). The model shall be designed with a modularity philosophy to integrate different active morphing devices (designed by other members) and the engine+nacelle scaled mockup (not operating). Model design will be driven by the need to reproduce the static elastic structural behaviour referred to real A/C.

Mechanical design and stress analysis for the estimation of the wing model deformation have to be carried out in accordance with WT requirements and in a closed loop with activities planned in Task 2.2 mainly responsible for the integration of the active adaptive devices with the designed NLF flexible wing.

As part of the design phase, starting from a baseline wing configuration (e.g in terms of position, size

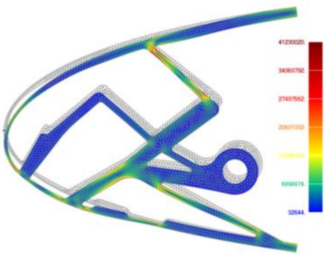
& setting of LC&A) provided by the R- IADP member, CFD based 3D aerodynamic optimisation of LC&A devices configurations in several flow conditions will be performed to find optimal loads distributions. Simulations are aimed to enhance the aerodynamic efficiency in climb and other off-design conditions as well as to alleviate wing bending moment, preserving laminar flow extent. Flow conditions for analyses are expected to range between Mach number [0.2 - 0.8], incidence angle [-4 / +4 deg] and high Reynolds number [10 - 20] 10^6.

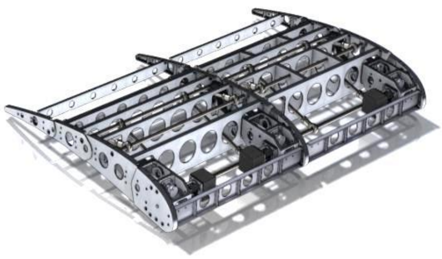
Task 2.2: Adaptive Devices and Instrumentation integration

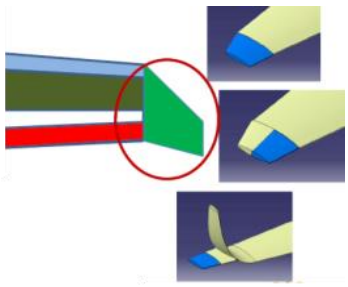
The model will be equipped with active LE, TE and wingtip morphing devices designed and manufactured by other REG IADP Members/Core Partners Therefore these are not part of the present topic. Nevertheless, a strong interaction between partners responsible for active devices is necessary to define and agree relevant model design approaches, interfaces and technical solutions allowing the integration of morphing devices in NLF flexible wind as designed in task 2.1 (e.g. morphing devices integrated in the model installed in the model could significantly affect the structural behaviour of the assembled model).

The following active adaptive wing devices have to be considered for integration activities:

- Droop nose LE: The morphing LE is composed by a compliant mechanism able to meet both kinematic (motion) and structural (load–carrying) requirements. The stiffness is optimally distributed into the skin and the internal structure so to produce the optimal deformed shape (aerodynamic requirement) once actuated.
- Morphing TE flap: The architecture is characterized by multi-body morphing structure based on articulated ribs driven by electro-mechanical actuators and properly designed to sustain the relevant aerodynamic loads expected in service.
- Wing Tip Concepts: The design of an advanced morphing Winglet device is planned for steady and dynamic operative conditions. The system will be therefore, used for active gust and manoeuvre load control alleviation.
-


Morphing LE concept


Morphing TE Flap concept


Morphing Wing tip concepts

As part of integration activities, dedicated studies are planned for the installation in the model with steady and unsteady pressure transducers. In particular, at least 200 steady pressure taps and 15-20 unsteady pressure sensors (such as Kulites) will be installed on the model for local steady and unsteady pressure measurements. The Applicant shall propose a suitable way to integrate instrumentation with minimal flow disturbance. Finally few accelerometers measuring wing tip accelerations will be installed for test security reasons in order to prevent possible occurrence of dynamic aero-elastic instability phenomena.

Task 2.3:Model Manufacturing and System Integration

This task is responsible for the manufacturing of the large flexible NLF wing. The challenge in the final assembly will be to provide a complete full flexible model respecting requirements for NLF technology. As second step of the activities different active devices as described in task 2.2 have to be integrated into the model. Prior to the delivery of the model, the quality of the assembled model shall be verified by means of dedicated inspections. For the assembled test article the following tolerances are required:

Parameter	**Required Accuracy**
Geometrical deviation (lengths)	0.25%
shape deviation (difference between real and design shape)	± 0.1 mm(x/c<=0.5) ± 0.2 mm (x/c>0.5)
Surface gap (gap between different assembled parts)	≤ 0.1 mm (x/c<=0.5) ≤ 0.2 mm (x/c>0.5)
Upstream step (step between different assembled parts)	≤0.05 mm
Downstream step (step between different assembled parts)	≤0.0 mm (upper surface) ≤ 0.05 mm (lower surface)
Smooth surface roughness	<0.25 µm (x/c<0.4) <0.5 µm (x/c>0.4)
Pressure Taps diameter	<0.5mm

Prior to the delivery of the model, ground tests to check the correct functionality of both the instrumentations and active morphing systems installed into the model have to be checked.

Task 3.1: Ground Vibration Testing

Ground Vibration Tests (GVT) will be performed in order to validate the Finite Element model used for the aeroelastic predictions and to ensure the safety of the model during the wind tunnel tests. The effective Static and Dynamic behaviour of the assembled flexible wing will be achieved before wind tunnel tests.

Task 3.2: Wind Tunnel Testing Support

The wind tunnel test campaign will be performed in a large European facility (large enough to install 5-6m wing model), selected by the Topic Manager. Indeed, the service of the WTT is not part of the present CfP (wind tunnel operating costs are excluded from the present project).

Nevertheless, the Applicant will provide support during the installation of the model in wind tunnel as well as during the whole test phases. The experimental setup definition, test planning, data analysis and reporting are activities in charge to the Applicant.

Tests are planned at low and high speed regime (Mach foreseen range ≈ 0.2 - 0.8) and high Reynolds numbers in order to validate in a representative environment both the laminar wing design integrating LC&A concepts and active high lift morphing systems.

The concerned tests will be split into following phases:

1. Phase #1 – Characterization and validation of NLF technology: This phase is aimed to the assessment of laminar boundary layer extent at high Reynolds and Mach numbers (ranging between 0.5 and 0.8) of the designed NLF wing reproducing the A/C airframe deformation and integrating LE and TE morphing devices. During tests, effects on the laminar flow extension of manufacturing peculiarities (such as steps and gaps, 3D rivet obstacles) and of presence of contaminants (insects smashing) will be investigated.
2. Phase #2 – Validation of NLF and LC&A technologies: This phase is aimed to the assessment of the effects that innovative active TE and wing tip devices have in reducing induced drag and the wing root bending moment. Tests are planned at high Reynolds and Mach numbers (ranging between 0.5 and 0.8). Effect of LC&A devices on the laminar extent will be also investigated.
3. Phase #3 – High Lift Conditions: This phase is aimed to validate at take-off and approach conditions the whole A/C configuration in terms of NLF wing high-lift design performance. Tests are planned in Mach range between 0.2 and 0.3 to validate the effectiveness of active Morphed LE and TE devices in High Lift conditions.

During tests, the following measurements are envisaged:

- Infrared (IR) and or Temperature Sensitive Paint (TPS) for Laminar/turbulent transition detection;
- Steady and unsteady pressure measurements;
- Aerodynamic forces balance measurements to gather lift, drag, pitching moment and roll (bending) moment;
- Model Deformation Measurements (MDM)
- Aerodynamic loads distributions (preference is given to advanced pressure plotting techniques such as PSP);
- LC&A movable surfaces hinge moment measurements. For morphing devices (Droop nose, Trailing Edge flap and Winglet) additional loads measurements shall be defined during devices development by other REG IADP Members/Core Partners;

3. Major deliverables / Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type(*)***	***Due Date***
Del 1.1	Project Final Status of Activities: This Document reports a summary of the technical and dissemination activities performed in the different phase of the project evidencing positive and negative aspects. Lessons "learnt" are highlighted.	R	M30
Del 2.1	Model Preliminary Design Report (PDR): the preliminary design of the model evidencing the main design solutions is delivered supported by preliminary stress verifications	R, D	M12
Del 2.2	Model Critical Design Report: the design of the flexible wing model integrating morphing system is delivered supported by extensive stress verifications	R, D	M18
Del 2.3	Model Manufacturing & Model Inspection Report: The wing models has been manufactured and assembled to integrate morphing devices. Ground checks supported by documentation are performed to check the model quality.	H, R	M25
Del 3.1	Wing WT model static and dynamic vibration tests report: GVT tests aimed to validate the Finite Element model used for the aeroelastic predictions and to ensure the safety of the model during the wind tunnel tests are performed. Comparisons between the FEM predictions and effective GVT results are highlighted. At GVT completion, the Applicant shall deliver the test article at Wind Tunnel Facility.	R,D	M27
Del 3.2	WT test plan: The wind tunnel and instrumentation setup for each test phase are described. The test matrix is agree with Topic Manager and WT specialist highlighting instrumentations	R	M27
Del 3.3	WT test Report: Based on the carried-out experimental and numerical data, this document will report a detailed analysis of wing performances in regards the different tested technologies (NLF, LC&A and Morphing).	R, D	M30

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Model Design: the design of the flexible NLF wing model integrating LC&A and HLD technologies is completed	R	M18
M2	Model testing on ground: The wing models has been manufactured and assembled to integrate LC&A and morphing devices. Tests on ground validating system functionality are performed. GVT tests are performed	R	M25
M3	Green Turboprop aerodynamic database: The experimental aerodynamic database concerning NLF, LC&A and morphing LE TE technologies is delivered._	R	M30

(*H=hardware, R=report; D=data,drawing)

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

- ✓ Managing capabilities for large european research projects.
- ✓ Use of advanced computational tools for 3D aerodynamic (CFD) and aero-elastic/structural analyses (CFD/CSM coupling) is regarded as a paramount requirement to correctly address the physical phenomena involved.
- ✓ Expertise in CATIA V5 software for aeronautical applications -
- ✓ Concolidated experience in designing and manufacturing of large flexible wind tunnel models
- ✓ Concolidated experience in design and manufacturing of large scale laminar wt model
- ✓ Experience in Wind tunnel test activities, data analisys and reporting
- ✓ GVT testing capabilities on large model

II. Aileron Actuation Subsystem using EMAs

Type of action (RIA or IA)	IA		
Programme Area	REG		
Joint Technical Programme (JTP) Ref.	WP 2.4		
Indicative Funding Topic Value (in k€)	1100 k€		
Duration of the action (in Months)	48 months	**Indicative Start Date**[15]	Q1 2017

Identification	Title
JTI-CS2-2016-CFP03-REG-01-03	**Aileron Actuation Subsystem using EMAs**
Short description (3 lines)	
Development of an Electro-Mechanical Actuator (EMA) for Aileron Subsystem for the Regional A/C. The following tasks are involved: Design, Development and Manufacturing of an Electro-Mechanical Actuator, of the associated Electronic Actuator Control Unit and of a dedicated Test Bench with Counter Load Capability.	

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

1. Background

The role of the IADP dedicated to regional aircraft is to validate the integration of technologies at a further level of complexity than currently pursued in Clean Sky GRA so as to drastically de-risk their integration on future products.

The Regional Aircraft IADP demonstrations will be built by integrating several advanced technologies and solutions, pursuing an integrated and synergic approach with the ITDs. In fact, several technological developments for Regional Aircraft will take place in Airframe and System ITDs in strong interaction and collaborative attitude with the other leaders.

In the R-IADP, the individual Technologies Developments for Regional A/C are arranged along with 8 "Waves" and several individual road maps which will be developed in synergy with other ITDs, in particular Airframe ITD and Systems ITD. The WBS for technologies development (WP2) within the R-IADP is the following:

- WP 2.1 ADAPTIVE ELECTRIC WING
- WP 2.2 REGIONAL AVIONICS
- WP 2.3 ENERGY OPTIMIZED REGIONAL AIRCRAFT
- WP 2.4 INNOVATIVE FCS

The high-level WBS of WP3 demonstration is the following:

- WP 3.1 AIR VEHICLE TECHNOLOGIES FTB#1
- WP 3.2 FUSELAGE / CABIN INTEGRATED GROUND DEMO
- WP 3.3 FLIGHT SIMULATOR
- WP 3.4 IRON BIRD
- WP 3.5 INTEGRATED TECHNOLOGIES DEMONSTRATOR FTB#2

This topic will address activities relevant to WP 2.4 INNOVATIVE FCS.

In particular the main technologies expected to be integrated and demonstrated within the WP 2.4 are the following:

- Advanced and affordable flight control system architecture for regional A/C
- Load Control and Load Alleviation System (sensors, Flight Control Computers, control laws and actuation for suitable aerodynamic devices)
- Electro Mechanical Actuation Sub-System

According to the above, the Iron Bird is expected to be the ground demonstrator of innovative technologies developed in WP2.4 of R-IADP.

2. Scope of work

In the framework of the WP2.4 Innovative FCS, the present Topic asks the Applicants to provide a proposal for innovative technologies in order to develop an Electromechanical Actuation Sub-System for a primary flight control surface.

Scope of the activities is to achieve advancement, beyond the current state-of-the-art, in the electromechanical actuation system technology (EMA) to make it suitable for a primary control surface of a Regional Aircraft.

It is envisaged that the future Load Control /Load Alleviation functions could be implemented also through the ailerons in addition to conventional anti-symmetrical functions used for aircraft roll control.

For Regional Aircraft applications, installation constraints are a critical feature. Proposed EMA solution shall have a very compact design, to make easy actuator fitting on the wing.

The second critical feature concerns the EMA jamming event. Technology and material progressess/innovations in the jam free design or in anti-jamming devices shall be evaluated and compared to mitigate this specific risk.

The third peculiar feature is the aim to drive the surface by 2 EMA's devices operating at the same time.

Activity shall mature technologies starting from TRL 3 up to TRL 5, reaching equipment/system integration and testing on the Iron Bird; consequently it will not be submitted to flight activity.

2.1. Responsibility definition

a) Applicant Role

Starting from Sub-System specification to be provided by Topic Manager Company, the selected Applicant shall provide:

- Sub-System Proposal inclusive of detailed architecture and of any data that demonstrate the compliance to Sub-System specification as defined by Topic Manager. A DRL shall be agreed to demonstrate the performed design activities.
- Design, development, manufacturing and integration of the Aileron Electromechanical Actuators (EMA's).
- Design, development, manufacturing and low level integration (for rig test) of Electronic Actuator Control Units (EACU's) supplied at 28V. The motor control shall be based on microprocessor technology and the relevant Low Level Software (i.e. qualified RT-OS, Boot and Loader) shall be provided. Application SW is under Topic Manager responsibility.
- EACU and EMA shall be submitted to pre-integration and acceptance tests at Applicant facility using a dedicated test SW developed by the Applicant.
- A sub-system modelization, agreed with Topic Manager shall be provided using

Matlab/Simulink tool.

- Definition of the Actuator Control Laws, Failure Detection and reconfiguration algorithms, Prognostic and Health Management (PHM) data. The actuator configuration shall keep into account the results of Health Monitoring and Control Loop/Performance studies.
- Definition and manufacturing of EMA Test Bench. The bench shall allow performing tests of EMA/EACU in stand alone mode and under a contrasting load in order to verify Control Loop and failure detection algorithms. Preferred design should use only mechanical/electric features to simulate contrasting loads. It will include data acquisition facility and additional sensors
- Applicant shall produce and delivery the units according to tables at para 8.0 .
- Prognostic and Health Monitoring activities, which consists of architectural studies, algorithm definition and experimental validation at Test Bench.
- Support during integration phase in stand alone Test Bench and in Iron Bird test campaign phase.

The EMA/EACU even if not certified for flight shall be representative in form, fit and function to an actual flight-worthy equipment. A representative number of environmental tests shall be performed: other requirement shall be considered during the development phase and shall be demonstrated by analysis.

b) Topic Manager Role

- Topic Manager will be in charge to develop the dedicated Application Software (APSW) resident on EACU.
- EMA and EACU integration will be under Topic Manager responsibility, which will carry out this activity on the provided dedicated Test Bench located in Topic Manager Company premises.

After the Sub-system Test Bench integration in stand alone mode, the EMA/EACU will be integrated into an Iron Bird rig.

Topic Manager Inputs to selected Applicant

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
1	Subsystem Specification and ICD	Doc.	T0 + 2

2.2. Design Requirements

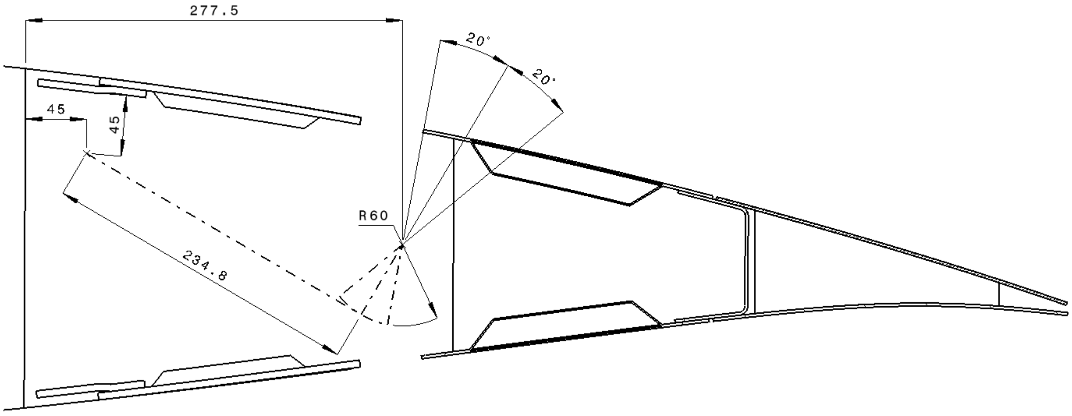
A list of the main requirements for the EMA and its associated EACU for an Aileron control surface actuation Sub-System design is provided in this section.

The Aileron Sub-System is composed by 2 EMA's that work normally at the same time, sharing the aerodynamic load in equal quantity. For this purpose a load equalization shall be foreseen in the system through suitable sensors and algorithms.
When one actuator is unoperative, its configuration shall be in damping mode.
With both actuators unoperative , they shall be in damping mode.
The actuation Sub-System shall be able to tolerate a jamming of one actuator or to demonstrate the jamming-free condition.

The EACU architecture shall be composed of two lanes arranged as a Control/Monitor Configuration.

The below figures are preliminary and shall be confirmed with the issue of Sub-System specification.
They shall be demonstrated also when only one actuator is operative :

- Aileron surface nominal travel = ± 20°
- Assumed arm = 60 mm
- Aileron actuator shall be designed in order to actuate the surface at 20 deg/s nominal rate against a surface hinge moment load of 1500 Nm,
- Position Frequency Response :
  - phase lag: > -20 deg @ 2Hz
  - gain : Min. -3dB, Max + 0.5 dB @ 2Hz
- Aileron surface inertia
  - $J = 2.16\ kgm^2$
- Ground Gust Load : 1200 Nm on surface (Limit Load). To be referred to actuator through lever arm.
- **Mass:** The total mass of the system composed by the two EMA's and the two EACU's, shall not exceed 20Kg
- **Space Envelope**
  Supposing an actuator configuration with reaction link. Actuator shall be installed inside the envelope showed in the following figure (this data is indicative as the installation studies are not yet started):



- **Power Consumption**
  - The maximum electrical power delivered to the EMA by the 270 VDC power supply shall be less than 800W (with one EMA operative). The actuator shall be capable to continuously sustain such an electrical power without damage.
  - EACU power consumption on 28 VDC shall be in the range of 80 W (this value will be further assessed with the Applicant during the development phase).

- **Serial Interface FCC/EACU**
  - Two EACU communication channels for command/monitorig (Time Triggered Protocol shall be considered as preferred serial interface, anyway the proposed serial interface will be confirmed with Sub-System specification) shall be provided. The EACU's shall have the capability to receive commands from the Test bench or from Flight Control Computers.

- **Safety**

  Sub-System/Equipment level Safety Analysis, with techniques developed and utilised in civil aviation certification, shall be produced on the basis of the hazard figures as for the following table:

Hazard	**Category**	**Objective**
Loss of one Aileron surface function	Major	1*10-6 FH^{-1}
Performance degradation of one Aileron surface	Minor	1*10-4 FH^{-1}
Aileron surface jam	Hazard	1*10-8 FH^{-1}
Aileron Surface hardover	Catastrophic	1*10-10 FH^{-1}
Aileron Surface free floating	Catastrophic	1*10-10 $FH^{-}1$

- **Software**

  DO 178 shall be used as guideline with DAL derived from Safety Analisis.

2.3. Test Bench Interface

On Topic Manager facility the following power supply will be available to supply the Test Bench:

For Test Bench power supply:

230 VAC @ 50 Hz

The following power supplies shall be provided by the Test Bench power supply:

For EMA motor power supply:

270 VDC

For Electronic Actuator Control Unit power supply:

28 V

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

Test bench recording capability

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

Mechanical Interface

The test bench shall accommodate the two EMA's and the two EACU's so, the test bench design and associated counter-load system shall comply with the EMA design and requirements.

Test Bench Functionalities

The test bench shall incorporate:

- An active counter-load system (inclusive of hydraulic generation if necessary).
- A stiffness and inertial-load simulating the control surface and the attachments. Adjustable stiffnesses for the test bench attachment (surface and structure sides) and the inertial load would be the proposed solution.
- A Test Bench Command System to generate and record the EMA commands and performance data;
- Capability to demonstrate the Sub-System performances in normal and degraded modes
- Capability of failure injection (including the capability of testing the anti-jamming device).
- Capability to demonstrate the PHM algorithm effectiveness

2.4. Qualification Activities

Fatigue/Endurance

The endurance test program shall be based on load/stroke duty cycles that will be specified to the Applicant with the Sub-System specification.
A scatter factor of 2 for Endurance and of 4 for Fatigue testing shall be applied to the duty cycles.

The useful life shall be demonstrated by analysis.

Environmental

The design goal for Aileron Actuation Subsystem is to achieve a full environmental qualification evidence in accordance with the applicable requirements of the DO-160 and, when required, MIL-STD-810G. Nevertheless, considering that the experimental activity would be performed only on ground (i.e., at the selected Applicant's premises, dedicated Test Bench and at Iron Bird facility), a limited qualification activity would be required
The EMA and its EACU shall be subjected to the following tests in accordance with the DO-160 to show compliance to the specified requirements:

- **Temperature / Altitude**
- **Vibration**

The detailed qualification test procedures will be agreed with the Applicant.
The other environmental requirements shall be kept into account into the EMA and EACU design, but not demonstrated by tests.

Electrical test

The following tests are requested by test for EMA/EACU:

Power Input Quality

The equipment shall satisfy the requirements of MIL-STD-704 Rev F.

Bonding

EMC/EMI

- **Emission of Radio Frequency energy**
- **Audio Frequency Conducted Susceptibility**
- **Induced Signal Susceptibility**
- **Radio Frequency Susceptibility (Radiated and Conducted),**
- **Magnetic Effect**

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D1	Performance Studies and Architecture definition	Doc.	T0 + 4
D2	Preliminary Health Monitoring Studies	Doc.	T0 + 4
D3	EMA Specification	Doc.	T0 + 4
D4	EACU Specification	Doc.	T0 + 4
D5	Control Law Definition	Doc.	T0 + 7
D6	Test Bench Specification	Doc.	T0 + 7
D7	Health Monitoring validation Plan	Doc.	T0 + 7
D8	EMA/EACU Interface Control Document + Design Document Package (Technical Description, Installation Drawings, Mass report, Safety Analysis)	Doc.	T0 + 7
D9	Detailed EMA/EACU Interface Control Document + Detailed Design Document Package (Technical Description, Detailed performance analysis Installation Drawings, Detailed drawings, Mass report, Safety Analysis)	Doc.	T0 + 12
D10	Functional Requirement Document and Modelization	Doc.	T0 + 12
D11	Test Bench Interface Control Document + Design Document Package (Technical Description, Installation Drawings, Manual)	Doc.	T0 + 12
D12	Final Health Monitoring Studies	Doc.	T0 + 12
D13	EACU prototypes delivery to Topic Manager Company for SW development (1 unit)	HW	T0 + 21
D14	Pre-Integration Test Report at Applicant premises	Doc.	T0 + 27
D16	EACU delivery to Topic Manager Company(3 units)	HW	T0 + 27
D17	EMA delivery Topic Manager Company (3 units)	HW	T0 + 27
D18	Test Bench delivery Topic Manager Company	HW	T0 + 27
D19	Model validation report	Doc.	T0 + 33
D20	Health Monitoring validation report	Doc.	T0 + 34
D21	Qualification activities report	Doc.	T0 + 48

Milestones		
Ref. No.	***Title – Description***	***Due Date***
M1	Sub-System Requirement Review	T0 + 4
M2	Preliminary Design Review	T0 + 7
M3	Critical Design Review	T0 + 12

Milestones		
Ref. No.	***Title – Description***	***Due Date***
M4	Test Readiness Review	T0 + 25
M5	Final DDP issue	T0 + 48

Applicant support at Topic Manager Company premises

The Applicant shall foresee technical support during the following phases:

1. Integration at Test Bench   from T0 + 27 to T0 + 36
2. Integration at Iron Bird   from T0 + 36 to T0 + 48

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

The Applicant(s) shall have:

- Demonstrated experience in design and manufacturing of airborne equipment qualified under RTCA-DO-160, RTCA-DO-178 and RTCA-DO-254 for critical equipment or other civil or military equivalent standard, to be used as guidelines for system development.
- Competence in the management of very articulated programme and capability of technical conduction of complex project.
- Proven experience in international R&D projects cooperating with industrial partners, institutions, technology centres, universities.
- Quality and risk management capabilities demonstrated through applications on international R&D projects and/or industrial environment.
- Capability in using advanced software environment able to trace all technical requirements and their relevant solutions (DOORS or equivalent Requirement Traceability Tool).
- Capability in using Matlab/Simulink.

More specifically the applicant(s) organization expertise and skills are required for:

- Electromechanical actuation and power electronics applied to aeronautical systems.
- Control loop and failure detection/reconfiguration algorithm definition.
- Prognostic and Health Monitoring Algorithm.
- Electrical and mechanical installation and integration.
- Complex test Benches Design and Manufacturing.
- Electronic HW Manufacturing Development and Qualification.
- Software Development and Qualification for Safety Critical Applications.
- HW-SW integration.

5. Abbreviations

APSW	Application Software
CfP	Call for Proposal
DAL	Development Assurance Level
DDP	Declaration of Design Performance
DRL	Data Requirement List
EACU	Electronic Actuation Control Unit
EMA	Electro-Mechanical Actuator
EMC	Electro Magnetic Compatibility
EMI	Electro Magnetic Interference
FCS	Flight Control System
FH	Flight Hour
IADP	Integrated Aircraft Development Platform
ITD	Integrated Technological Demonstrator
LA/LC	Load Allevation/ Load Control
PHM	Prognostic & Health Management
R-IADP	Regional Integrated Aircraft Development Platform
TRL	Technology Readiness Level
WBS	Work Breakdown Structure
WP	Work Package

II. Development and delivery of a flexible assembly system based on reverse engineering, tolerance analysis and Determinant Assembly Approach of wing box

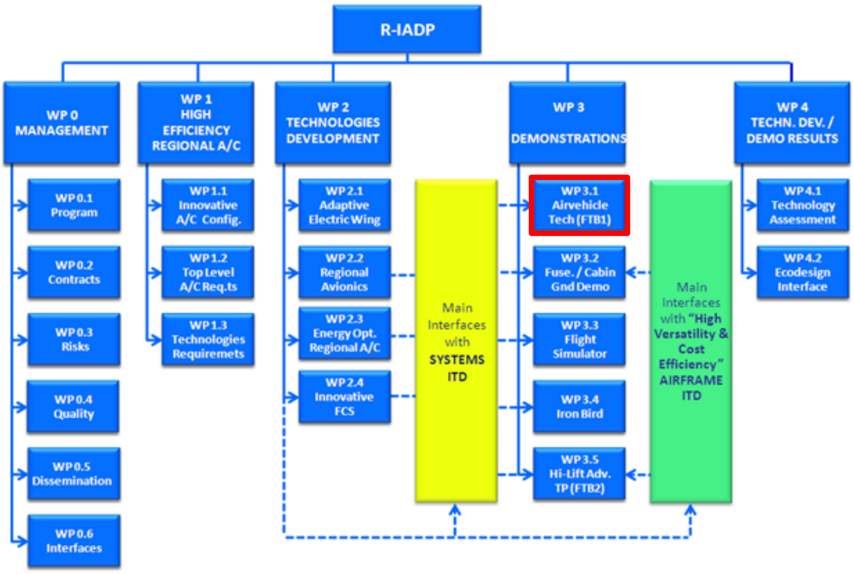
Type of action (RIA or IA)	IA		
Programme Area	REG		
Joint Technical Programme (JTP) Ref.	WP 3.1		
Indicative Funding Topic Value (in k€)	1700 k€		
Duration of the action (in Months)	36 months	**Indicative Start Date**[16]	Q1 2017

Identification	Title
JTI-CS2-2016-CFP03-REG-01-04	**Development and delivery of a flexible assembly system based on reverse engineering, tolerance analysis and Determinant Assembly Approach of wing box**
Short description (3 lines)	
The system shall be capable to scan surfaces and holes of several areas along the wing. Using a virtual best fit software, holes and surfaces will be replicated on mating components in order to perform the assembly via the part to part assembly approach in virtual and real environments.	

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

1. Background

Activities to be performed according to the present Topic description are included in a wider context of work in the framework of the Regional Aircraft IADP of Clean Sky 2. In particular, the Work Package 3.1 "Airvehicle technologies (FTB1)" represents the field where activities requested to the Applicant shall be performed. The relevant Work Breakdown Structure is shown below putting in evidence the WP 3.1:



2. Scope of work

The scope of the activities is to deliver a complete system that, starting from full size holes and smooth surfaces on the wing skins, will be able to produce a suited output for CN part program generation aimed to drill and machine mating features on the ribs.

Main activities that will be required are:

- Characterization of process variability on samples
- Tolerance optimization on the digital mock-up
- Development of the scanning equipment
- Development of the virtual best fit software
- Integration of the systems with standard facilities
- System fabrication and valisation on phisical mock-up
- Support and training on the assembly site

Activities shall be diveded in the tasks listed in the folloeing table:

Tasks		
Ref. No.	***Title – Description***	***Due Date***
1	Variability analysis and characterization for process tolerances.	T0+6
2	Capability assessment and tolerance optimization using CATIA based Computer aided tolerance (CAT) software	T0+18
3	Identification of best technical solutions for equipment and systems and preliminary lay-outs of the equipment	T0+6
4	Software design	T0+18
5	Equipment design	T0+15
6	Equipment manufacturing and integration	T0+24
7	System validation on dummy parts	T0+27
8	On-site installation	T0+30
9	Fine tuning of the equipment on the full scale demonstrator and training	T0+36

Task 1 - Variability analysis and characterization for process tolerances

The partner shall conduct a statistical analysis to define natural variability range and distribution resulting from production samples in composite material (CFRP) and metal provided by Topic Manager. The manufacturing tolerances to be assessed as a reference will be:

- surface flatness from machining of CFRP and metal;
- hole position and diameter on CFRP and metal;
- floating between hole and bolt/screw into different reaming class conditions,
- trim shape on CRFP and metal.

Position of datum pins and shape of stop tabs from the tooling shall also be considered.

The desired output for the activity will be a guideline to assign standard tolerances values to datum and other key features on the wing components that will be used during the part to part assembly simulation.

Task 2 - Capability assessment and tolerance optimization using CATIA based computer aided tolerance (CAT) software

The partner shall conduct statistical analysis over the digital mock-up and relevant tolerances provided by Topic Manager using a CATIA based Computer Aided Tolerance (CAT) software. The first study shall integrate tolerances resulting from the characterization (first task) with the additional variability introduced by the innovative equipment and with the assembly method provided by Topic Manager. Using these best values, the dimensional capability of the overall assembly process on selected key assembly/measure points (KPIs) shall be measured. A second analysis will be then conducted to increase tolerance ranges along non critical variability paths to the values that still satisfy the desired capability on KPIs with a defined confidence level.

The output of this task will be a document that demonstrates the capability of the assembly process when certain design tolerances are satisfied on detail parts. If the tolerance analysis will fail at some locations, small indexing fixtures will be developed and validated through the same CAT study.

Task 3 - Identification of best technical solutions for equipment and systems and preliminary lay-outs of the equipment

The partner shall identify the most appropriate technologies and sensors that can be integrated into the assembly system to successfully achieve dimensional requirements for the final product. The system can be represented by three separate functionalities that shall be integrated into an assembly cell prototype:

- Reverse engineering module: A scanner (optical or laser) that will be used for reverse engineering holes and smooth surfaces (typically ribs and skins). The system shall ensure 0,006 mm or better accuracy on CFRP without applying any aid on the parts like spray or tape. Scanning hardware will perform automated routes for scanning.
- Adaptive Jigs: Jigs will be necessary to firmly hold both wing skins at the scanning/assembly stage.
- Software for virtual best fit: The software, starting from the scanned features on the skins, shall act as a virtual indexing Jig to simulate a best fit positioning ensuring tolerances on KPIs**.** Subsequently holes and surfaces at rib assembly locations will be extrapolated to allow building the machine & drill part program for the ribs in the nominal position.

Task 4 - Software design

Diameter, angularity and position of holes will be evaluated, as well as the surface at mating areas. Other KPIs like aerodynamic surfaces and further assembly areas will also be scanned. Those surfaces will be used to build a reverse-engineered model of the skins. Both skins will be mounted and best-fitted via software on a virtual jig to ensure KPIs tolerances. Then a routine shall evaluate shim shape and hole pattern on blank mating parts. A standard file for drill & machine part program generation shall be produced as an output for precise drilling and machining ribs at interface areas. Software shall be reconfigurable to be used for other reverse engineering activities.

Other software is required to program the route of scanning system, path shall be reconfigurable to extend operability and allow adjustment during the final use. All software developed shall be compatible with Topic Manager IT standard for design and post-processing (Catia, Jobs, DMG, ...).

Task 5 - Equipment design

Equipment is intended composed of skin measure/assembly jig and scanning hardware. The jig shall firmly hold the skins through datum interfaces at the scanning stage. At assembly stage, indexing of the parts will be driven by full size DA holes and precise machined surfaces. Jigs shall then allow some degree of freedom to accommodate small adjustments for manual indexing. The scanning system shall be moved by a stand-alone automated handling system. All equipment and tooling shall be designed to be integrated within Topic Manager facility, using available industrial utilities and capital equipment. Ergonomic evaluations shall be performed to gain accessibility at any assembly level.

Task 6 - Equipment manufacturing and integration

Equipment and tooling shall be manufactured according to CE safety regulations. The manufacturing will involve hardware and software integration to build stand-alone equipment for scanning, complete software for processing data and an assembly/measure jig. The three systems shall be fully integrated to constitute a complete assembly cell including PC for data processing analysis and equipment control.

Task 7 - System validation on dummy parts

A dummy physical mock-up shall be designed and manufactured. The mock-up can be made either in MDF (wood), or CFRP, or in any other suitable material. The shape of the mock-up shall be representative (but not necessarily a carbon copy) of the wing's features. The assembly cell shall be tested for acceptance at manufacturer facility. Completing the assembly on the dummy physical mock-up will be an acceptable demonstration of capability.

Task 8 - On-site installation

Subsequently to positive acceptance results, the whole equipment shall be shipped and installed at Topic Manager facility by the partner.

Task 9 - Fine tuning of the equipment during the full scale demonstrator and training

The partner shall support Topic Manager on site during the first wing box demonstrator assembly. The support will include fine tuning necessary to solve any issue related to the assembly cell that will be identified. Training on the job will also be included to allow Topic Manager full operability on the cell. Maintenance and guaranty will be defined per contractual agreements.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D1	Production tolerances characterization	Report	T0+6
D2	Preliminary capability analysis using natural process variability	Report	T0+15
D3	Final capability analysis including tolerance allocation for single parts	Report	T0+18
D4	Guidelines for assembly cell lay-out	Report	T0+6
D5	Assembly cell acceptance report	Report	T0+27
D6	Assembly cell as built documentation and operative manuals	Report	T0+30
D7	Assembly cell as built documentation and operative manuals	Report	T0+36
D8	Assembly cell delivery	Hardware	T0+30
D9	Final demonstrator assembly report	Report	T0+36

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M1	Tolerance definition	Report	T0+18
M2	Acceptance tests on dummy Mock-Up	Report	T0+27
M3	Preliminary lay-out definition	Report	T0+6
M3	Complete cell delivery and on-site installation	Hardware	T0+30
M4	Assembly cell as built documentation and operative manuals	Report	T0+36

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

- Designing and modeling using Dassault CATIA software
- Tolerance studies using Dassault CATIA modules (DCS software will be preferred)
- Proven competence over reverse engineering application
- Advanced tooling design and tooling automation
- Advanced software design and software integration
- Tooling and equipement fabrication, integration and installation
- General Knowledge of aeronautical assemblies technologies and requirements using CFRP components

3. Clean Sky 2 – Fast Rotorcraft IADP

I. Development and Demonstration of a High Power Density Homokinetic Drive Joint for Civil Rotor Applications

Type of action (RIA or IA)	IA		
Programme Area (ref. to SPD)	FRC		
Joint Technical Programme (JTP) Ref. (ref. to Work Package)	WP 1.1, 1.2		
Indicative Funding Topic Value (in k€)	750 k€		
Duration of the action (in months)	48 months	**Indicative Start Date[17]**	Q1 2017

Identification	Title
JTI-CS2-2016-CFP03-FRC-01-02	**Development and demonstration of a high power density homokinetic drive joint for civil rotor applications**
Short description (3 lines)	
The objective is to deliver flight cleared homokinetic drive units for civil tiltrotor proprotors. Representative test items will be used for structural and environmental testing and the flight cleared components will be integrated in the tiltrotor rotor system.	

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

1. Background

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

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

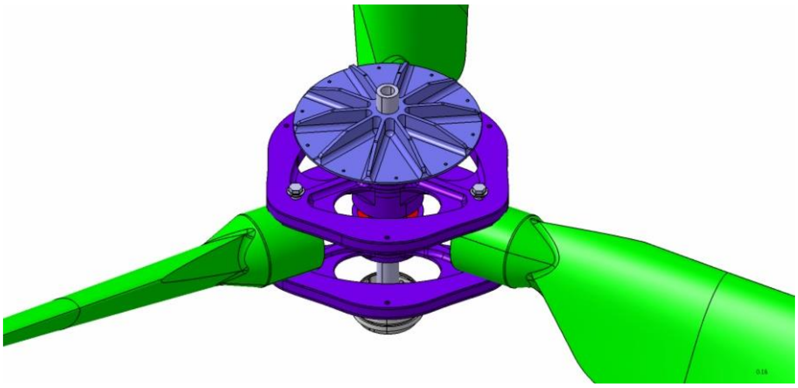


Figure 5: Rotor system at neutral position (0 deg blade flap)
For illustration purposes only, design subject to change

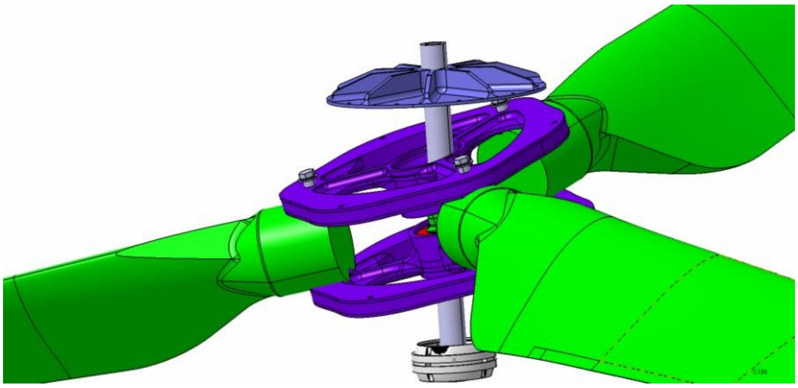


Figure 6: Rotor System with 11 deg blade flap
For illustration purposes only, design subject to change

2. Scope of work

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

The compact drive unit will transmit power across a range of torque and RPM values, while allowing the misalignment between the driving rotor mast and the driven hub plane. The homokinetic joint will need to accommodate the range of proprotor flapping motion and any transient torque from flight manoeuvres.

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

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T0	Project Management	T0-T0+48
T1	Design and Development of a homokinetic drive unit.	T0-T0+12
T2	Manufacture of specimens for characterisation testing	T0+12-T0+18
T3	Characterisation testing	T0+18-T0+24
T4	Updating of the homokinetic drive unit design according to characterisation test results and evolution of the overall rotor design	T0+24 -T0+30
T5	Manufacture of prototype for structural testing	T0+30 -T0+36
T6	Structural endurance testing	T0+36 -T0+42
T7	Manufacture of flight hardware	T0+42 -T0+46
T8	Support to obtaining Flight Clearance	T0+42 -T0+48

Further details related to specific activities are given below:

Task T0:

Accounts for ongoing project management of the programme.

Task T1:

The Topic Manager will provide information on the material and geometry of the interface with the hub.

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

- Reference Max continuous power:
  5000 shp
- Transient power capability:
  10000 shp
- Working RPM:
  450 -500 RPM

- Space envelope:
  External Diameter < ~350mm
  Internal Diameter to accommodate mast ~170 mm

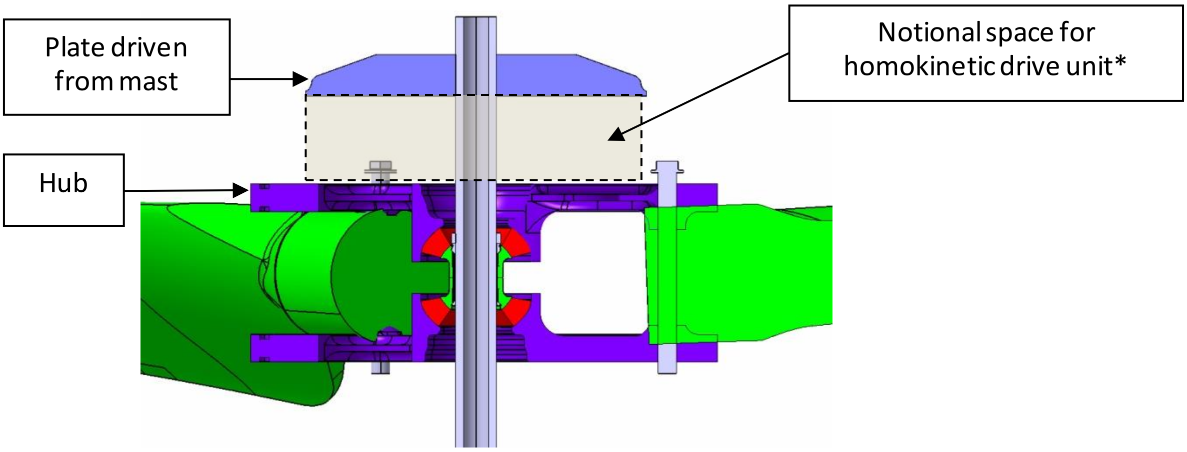


Figure 7: Notional space envelope for homokinetic device

* Designs that include a homokinetic device integrated with the hub will be considered.

- Maximum motion range:
  ±11° Flapping

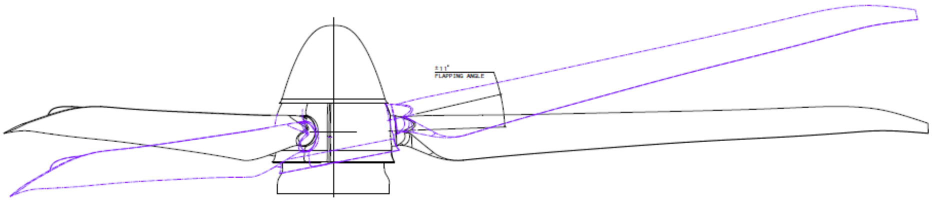


Figure 8: Illustration of max flapping angle

- Damage tolerant design that complies with civil certification requirements.
- Minimum weight to fulfil functional requirements

Task T2:

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

Task T3:

Where applicable, characterisation testing on coupons and structural elements will be conducted to validate strain performance of the chosen materials under the expected operating range of temperature and humidity.

The results from characterisation testing will be assessed by the Topic Manager in the context of the development of the overall rotor system design.

Task 4:

Task 4 is to account for a second iteration loop that refines the design of the homokinetic drive according to the evolution of the rotor system. This task includes assessment of the impact of any refinement in loads. On the basis of this assessment, any refinement to the design will require analysis and where applicable, testing of representative samples to substantiate any differences.

Task T5:

At least two (2) off prototype homokinetic drive units will be manufactured for structural testing at a location agreed between the Partner and the Topic Manager.

Task 6:

Structural testing of the representative specimens will be conducted to validate predicted fatigue behaviour. Results of the test will be used to manage inspections and removal of the assembly. Where applicable, limit and ultimate load static testing will also be required to substantiate the structural performance of the assembly.

Task 7:

Manufacture of at least two (2) off homokinetic drive units for the flying demonstrator aircraft.

Task 8:

The partner will support achievement of flight clearance through reporting test and analysis results that substantiate the homokinetic device.

General Remarks:

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

Development of the homokinetic unit will be conducted in close co-operation with the Topic Manager.

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

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Concept	Document/Report	T0+8
D2	Detailed Drawings	Document/Report	T0+12
D3	Availability of specimens for Characterisation Testing	Hardware	T0+18
D4	Assessment of strain characteristics	Document/Report	T0+24
D5	Availability of prototype for endurance testing	Hardware	T0+36
D6	Endurance Test Report	Document/Report /Presentation	T0+42
D7	Availability of flight hardware	Hardware	T0+46
D8	DDP for Flight Clearance	Document/Report	T0+48

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	PDR	Design Review	T0+8
M2	CDR (TRL of at least 5 for each system, technology and manufacturing process proposed)	Design Review	T0+12
M3	Availability of test specimens for characterisation testing	Hardware Availability	T0+18
M4	Characterisation test report	Document	T0+24
M5	Availability of prototype for endurance testing	Hardware Availability	T0+36
M6	Structural Test Report	Document	T0+42
M7	Delivery of flight hardware for installation into Rotor Assy	Hardware Availability	T0+46
M8	Flight Clearance (TRL-7 for each system, technology and manufacturing process)	Flight Readiness Review	T0+48

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

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

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

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

Special Skills

- Competence in management of complex projects of research and manufacturing technologies.

- Experience in design and manufacture of constant velocity joints.

- Design, analysis and configuration management tools of the aeronautical industry (i.e. CATIA v5 release 21, Abaqus, VPM)

-Analytical vs Experimental correlation capability

- Experience with TRL Reviews or equivalent technology readiness assessment techniques in research and manufacturing projects for aeronautical or automotive industry

- It is desirable to have proven experience in collaborating with reference aeronautical companies with industrial air vehicle developments with "in – flight" components experience.

- Capacity to support documentation and means of compliance to achieve experimental prototype "Permit to Fly" with Airworthiness Authorities (i.e. EASA, FAA and any others which may apply).

- Capacity to specify material and structural tests along the design and manufacturing phases of aeronautical components, including: material screening, and instrumentation.

- Capacity to perform structural and functional tests of aeronautical components: test preparation and analysis of results

- Capacity to repair "in-shop" components due to manufacturing deviations.

- Capacity of performing Life Cycle Analysis (LCA) and Life Cycle Cost Analysis (LCCA) of materials and structures.

- Capacity of evaluating design solutions and results along the project with respect to Ecodesign rules and requirements.

- Design Organization Approval (DOA) is desirable

- Product Organization Approvals (POA) is desirable

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

- Qualification as Material and Ground Testing Laboratory of reference aeronautical companies (i.e. ISO 17025 and Nadcap).

- Advanced Non Destructive Inspection (NDI) and components inspection to support new processes in the frame of an experimental Permit to Fly objective.

Material and Processes

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

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

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

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

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

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

II. Next generation smart active inceptors for a civil tiltrotor

Type of action (RIA or IA)	IA		
Programme Area (ref. to SPD)	FRC		
Joint Technical Programme (JTP) Ref. (ref. to Work Package)	WP 1.1, 1.6		
Indicative Funding Topic Value (in k€)	1500 k€		
Duration of the action (in months)	48 months	**Indicative Start Date**[18]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-FRC-01-07	**Next generation smart active inceptors for a civil tiltrotor**
Short description (3 lines)	
The present activity involves the design, development, manufacture and qualification of smart fly-by-wire active inceptors for the future generation cockpit of a civil tiltrotor. The designed units will be subjected to test pilots' functional and ergonomic assessments, qualified for experimental flight clearance and integrated in the tiltrotor flying demonstrator.	

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

1. Background

The aim of the Fast Rotorcraft (FRC) project is to use technologies developed through the Clean Sky Programme to demonstrate a compound rotorcraft configuration that combines the vertical lift capability of the conventional helicopter with the speed capability of a fixed wing aircraft in a sustainable way. 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 cockpit inceptors. The present document describes also the general requirements that JU shall consider for the selection of the appropriate Partner(s) for this technology development.

Active inceptors are considered extremely appealing by pilots' community due to the increased situational awareness that these controls allow to achieve on highly augmented Fly By Wire aircrafts, with respect to passive sticks. Although active inceptors technology has reached a level of maturity adequate to allow deployment onto civil aircrafts, the most part of the commercially available active stick units relies on conventional avionic interfaces (analogue, ARINC 429, etc.). Typically, modern active stick units embed sufficient processing capability to control and monitor the active force-feel features of the controller, whereas they make use of Flight Control Computer I/O and processing capability to demodulate, monitor and select/vote the redundant flight critical stick positional sensor signals. Tiltrotor NextGen CTR will exploit an innovative Flight Control System design based on distributed processing power and high-speed digital broadcasting between Flight Control Computers and "smart" Flight Control equipments. The NGCTR cockpit flight controls will be hence required to operate as "smart" devices and to be interfaced with this innovative avionic architecture.

2. Scope of work

The main objective of this technology line is to design, develop, and manufacture the cockpit inceptors system needed to translate the NGCTR pilots' basic inputs (pilot and co-pilot) into suitable digital commands to the aircraft Fly-By-Wire Flight Control System, whilst providing adequate cues to the crew. The activity of the present call shall culminate with the integration of the inceptors system into the NGCTR demonstrator vehicle and the achievement of SOF (Safety of Flight) qualification of the equipments in order to permit the demo flying activities.

The envisaged NGCTR cockpit controllers will encompass the following items:

- 2x Active Side-Stick controllers: the two-axes sidestick inceptors will exploit the embedded active features to provide adaptive force feel characteristics to the pilots, and to maximize situational awareness through programmable tactile cues (soft-stops, hard-stops, stick shaker, pusher, etc.) and force coupling across cockpit seats.
- 2x Active Throttle / Power Lever: the single axis throttle controllers will be required to provide similar active force-feel features of sidestick unit, including force coupling between

pilot's and co-pilot's grips.

- 2x Passive (preferably) Pedal units: mechanically centred (unique trim) and coupled, will be required to provide a basic force feel whilst electrically transducing yaw axis command or commanding landing gear brakes.

As previously mentioned, the cockpit flight controls will be smart devices interfaced to the NGCTR Flight Control System and general avionics through a state-of-art digital high-speed network (such as one based on time-triggered protocols, TTP, TTEthernet, etc). As smart devices, the inceptor control units will ensure adequate self-monitoring and failure isolation capability. The inceptors will be then asked to provide the following core functions with the necessary level of integrity:

a. Sidestick, Throttle and Pedal: Transduce safety critical pilots' inputs to Flight Control System in a digital format. The inceptor control units will be designed to condition, demodulate (if applicable), A/D convert, monitor and select the position information, from the various redundant sensors (L/RVDTs, resolvers, digital encoders, potentiometers, etc.), to be used by the Tiltrotor Control Laws. Design dissimilarity and other safety provisions will be implemented to make sure that single or combined failures (within processing domain, electrical domain or mechanical domain) causing the pilot's command to get stuck, lost or corrupted are either probabilistically irrelevant or extremely remote. For instance, since the redundant interfaces between AIS and FCS are moved from analogue to digital domain, the related HW will be complex and thus generally susceptible to common mode failures. The multiplex redundant (e.g.: triplex) digital interface components should be instead robust against common mode failures, thanks to dissimilar design or to other specific design characteristics.
b. Sidestick and Throttle: acquire, monitor, select and transmit to Flight Control System the discrete signals read from grip switches.
c. Pedal: acquire, monitor, select and transmit to Landing Gear System the discrete signals commanding brake actuation.
d. Sidestick and Throttle: Provide programmable force-feel characteristics and tactile cues through low-cogging, high-performance electrical motors, high efficiency reduction gears (if necessary) and embedded power electronics. The force-feel settings shall be modifiable in run-time upon Flight Control System request. The general self-diagnostic capability of the inceptor smart control unit will encompass the redundancy management of force transducers (if any) used to enforce the desired static and dynamic stick behaviour, and to guarantee the force-coupling functionality. Should a specific failure scenario occur preventing the continued operation of the inceptor in active mode, the inceptor will be designed to switch into a safe passive degraded mode. This reversionary mode will provide a basic force-feel characteristic.
e. Pedal (if passive): provide a basic, constant force-feel law by mechanical means (i.e. break-out, force gradient and soft-stop).

Besides the effort for designing and implementing an efficient, compact and lightweight inceptors solution, the Applicant/s will be required from the very beginning of the project to operate closely with WAL specialists and test pilots to optimize the ergonomic design, installation into the NGCTR cockpit, and to ensure that the required qualitative and quantitative safety requirements are met. Safety-wise, dual pilot operation will be required for NGCTR flying activities, nevertheless the Applicant/s will be asked to design an active inceptor system open as much as possible to potential future single pilot aircraft variants. The impact of relevant safety provisions (if any) and qualification aspects will be thoroughly analysed and discussed with WAL. Finally, in order to support NextGen CTR Flight Control System development and integration tasks, the Applicant/s will develop, share with WAL and maintain a modeling and simulation tool of the flight control inceptors.

The detailed requirements for the system interfaces with the aircraft shall be part of dedicated discussion with selected Partner(s), following the signature of dedicated NDA or equivalent commitment.

Tasks		
Ref. No.	***Title - Description***	***Due Date*** [T0+mm]
T0	Concept exploration starting from high-level system requirements(1); definition of inceptors configuration and detailed system requirements in support of Active Inceptors System Requirement Review.	T0+2
T1	Development of smart inceptors configuration and support of Preliminary Design Review. Preliminary digital mock-up models (DMU) and simulation models are prepared in support of PDR.	T0+4
T2	Definition and development of detailed HW (inceptor bodies and control units) and SW design (SCUs embedded SW), support to smart inceptors Critical Design Review; the simulation models and analysis tools undergo a significant review and refinement process, the level of complexity is agreed between WAL and the Partner/s.	T0+16
T3	Implementation of HW/SW design consolidated at CDR. The HW is manufactured (mock-ups / A models), the SW coded and tested, and the equipments are experimentally validated at Partner's premises.	T0+26
T4	Fully representative rig units (B1 models – EFA candidates) are manufactured, incorporating feedbacks from A models into B1 design standard. Support to WAL for integration into Flight Control System rig and into TDTR (Tied Down Tilt-Rotor) cockpit, at WAL's facility.	T0+37
T6	Agreement of qualification test procedures and support to inceptors Test Readiness Review for EFA qualification.	T0+44
T7	EFA qualification testing (environmental and functional qualification of HW, formal SW testing and qualification). Manufacturing of EFA flight-worthy units (B2 models) for WAL, incorporating possible feedbacks coming from qualification activities into B2 design standard. Preparation of Qualification Test Reports and Declaration of Design and Performances (DDP) to allow start-up of experimental flight trials.	T0+48
T8	Support to IADP flight activities and continued airworthiness (PRs closure and support to flight data analysis); conclusion	T0+66

(1): High-level System Requirements will be provided to the selected Partner(s), following the signature of dedicated NDA or equivalent commitment, as part of the techincal discussions between the Partner(s) and AW that will take place after the selection phase (T0).

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date*** [T0+mm]
D.1	Concept Exploration & Definition	R	T0+2
D.2	Configuration development and Preliminary Design Review deliverables	R / D	T0+4
D.3	Detailed HW and SW design, Critical Design Review deliverables	R / D	T0+16
D.4	Validation Reports	R	T0+26
D.5	Fully representative rig units (EFA candidates, B1 models), provided with a Preliminary DDP	D	T0+37
D.7	Technical documentation supporting TRR, Qualification Test Plan and Procedures	R	T0+44
D.8	Qualification Test Reports, EFA DDP	R	T0+48
D.9	EFA shipset (B2 models) and spare units	D	T0+48
D.10	Amended design documents according to flight trials results	R	T0+66

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

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date*** [T0+mm]
M1	System Requirement Review	RM	T0+2
M2	Preliminary Design Review	RM	T0+4
M3	Critical Design Review	RM	T0+16
M4	Test Readiness Review	RM	T0+44
M5	Experimental Flight Approval	R / D	T0+48

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

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

As a general remark, it is highly recommended that the proposed technologies have at least TRL 4 at T0. Moreover, the Applicant(s) shall own the following pedigree and special skills:

- ✓ Compliance to SAE AS9100.
- ✓ Experience of aeronautic rules, certification processes and quality requirements.

- ✓ Experience in design, validation, manufacturing and environmental/functional qualification of airborne equipments, either cockpit flight control systems, 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.
- ✓ Familiarity with EMI compatibility issues: capacity to design complex electronic HW in compliance with EMC guidelines, and experience in performing EMC justification analyses and experimental assessments according to RTCA-D0-160, EUROCAE ED-107/ARP-5583, ED-81/ARP-5413 and ED-84/ARP-5412 or equivalent civil or military standards (TBC).
- ✓ Experience in research, development and manufacturing (or integration) in the following technology fields:
    - o Cockpit flight controls, with particular emphasis on active stick design as per SAE-ARP-5764 guidelines.
    - o High performance DC brushless servomotors and drive systems,
    - o Compact and reliable sensors and switches.
    - o High integrity control electronics.
    - o Grip ergonomic design and optimisation.
- ✓ Well proven engineering and quality procedures capable to produce the necessary documentation and means of compliance to achieve the "Safety of Flight" with the applicable Airworthiness Authorities (FAA, EASA, etc.).
- ✓ Design Organization Approval (DOA) desirable.
- ✓ Experience in Safety assessment process according to SAE-ARP-4754 and SAE-ARP-4761 standards, willingness to interact closely with WAL safety specialists in order to produce the necessary outputs (safety and reliability reports and fault trees/analyses).
- ✓ Shape, component design and structural analysis using CATIA v5 and NASTRAN, or compatible SW tools.
- ✓ Capacity to optimize the HW and SW design, to model mathematically/numerically complex mechatronic systems with suitable simulation tools (Matlab/Simulink, Dymola/Modelica, etc.) and to analyze both simulation and experimental results to ensure that the various required performance goals are met.
- ✓ Capacity to repair "in-shop" equipment due to manufacturing deviations.

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

5. Abbreviations

AIS	Active Inceptor System
BIT	Built In Test
CAN	Controller Area Network
CDR	Critical Design Review
CS2	Clean Sky 2
DAL	Design Assurance Level
DDP	Declaration of Design and Performance
DMU	Digital Mock Up
DOA	Design Organization Approval
EFA	Experimental Flight Approval
EMC	Electro-Magnetic Compatibility
EMI	Electro-Magnetic Interference
FBW	Fly By Wire
FCS	Flight Control System
FRC	Fast RotorCraft
IADP	Innovative Aircraft Demonstrator Platform
ITD	Integrated Technology Demonstrator
JU	Joint Undertaking
FPP	Key Performance Parameters
NDA	Non Disclosure Agreement
NGCTR	Next Generation Civil TiltRotor
PDR	Preliminary Design Review
PR	Problem Report
SCU	Stick Control Unit
SOF	Safety of Flight
SRR	System Requirement Review
TBC	To Be Confirmed
TBD	To Be Defined
TTP	Time Triggered Protocol
TRL	Technology Readiness Level
TRR	Test Readiness Review
WAL	Work Area Leader

III. High Speed HVDC Generator/Motor

Type of action (RIA or IA)	IA		
Programme Area (ref. to SPD)	FRC		
Joint Technical Programme (JTP) Ref. (ref. to Work Package)	WP 1.1 and 1.6		
Indicative Funding Topic Value (in k€)	1000 k€		
Duration of the action (in months)	66 months	**Indicative Start Date**[19]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-FRC-01-08	**High Speed HVDC Generator/Motor**
Short description (3 lines)	
Design, development, testing and flight qualification of a high speed / high voltage direct current (HVDC) generator system with an integral motor function to be installed onto the Next Generation Civil Tilt Rotor.	

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

1. Background

The aim of the Fast Rotorcraft (FRC) project is to use technologies developed through the Clean Sky Programme to demonstrate a 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 HVDC generator/motor. 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 function of any electrical generation system within an aircraft is to provide electrical power from the main aircraft electrical power sources, through the primary busbar arrangement, to the electrically powered equipment in a safe and efficient manner and in accordance with the appropriate power supply quality standards. With the introduction of the more electric aircraft there are significantly greater electrical loads on the aircraft, with electrical power being used for more flight critical applications that were previously hydraulic or air powered. This together with the standard requirements of reduced weight, increased reliability and easier maintainability lead to the requirement for a HVDC primary power systems architecture.

2. Scope of work

The main objective of this CfP is to design, develop, and manufacture a new compact, low weight high efficiency, high speed HVDC generator to act as a primary power source for the Tiltrotor NextGen CTR. The generators will be mounted on the fixed engine gearboxes and/or the mid wing gearbox and will be driven at a speed proportional to proprotor speed. The nominal speed is considered to be 24000rpm. The HVDC power from the generator (±270VDC) will be supplied to the electrical power distribution system for distribution to the respective loads, including flight safety critical loads. Control of the generator will be ideally provided by an integral Generator Control Unit (GCU) or controller (dependant on generator technology), however a separate unit may be considered if suitable justification can be provided.

As a secondary function, the generator shall also be able to act as a motor to drive various accessories through the aircraft gearbox, whilst on the ground. In this configuration, HVDC power will be provided to the controller, from the APU generator. The controller shall provide all the control and protection functions required for this operation.

The system shall be designed such that the main functionalities and performance are guaranteed throughout the whole aircraft flight operation, whilst ensuring adequate safety levels are maintained. Consideration needs to be given to the requirement for civil certification, safety, electrical power supply quality, high speed containment, mission reliability and availability, testability and maintainability.

It is extremely important that the operational status of the generator system is understood during all the flight phases and operational conditions of the aircraft. Therefore the equipment needs to incorporate extensive health monitoring, including PBIT, CBIT and IBIT, that can be used to optimize maintenance actions and failure detection.

Implementation

The HVDC generator requirements can be considered in two parts:

a) HVDC Generator Requirements

The HVDC generator shall provide a nominal ±270VDC output, incorporating any necessary rectification and control/HUMS sensors. The unit shall have the required drive pad and drive spline for interface with the gearbox and shall incorporate a drive shaft shear section to prevent damage to the gearbox in the event of a generator seizure. Cooling of the unit shall be via an integral cooling system with no direct use of the transmission cooling system. Improved time between overhaul shall be achieved using advance bearing technology with the aim to achieve a mean time between overhaul (MTBO) of 7500 Hrs.

The main characteristics of the HVDC generator shall be as follows and shall be confirmed during the initial evaluation concept phase:

Characteristic	**Requirement**
Nominal Power	90kW
Nominal Voltage	± 270VDC
Nominal Speed (100%)	24000 rpm
Speed Range	70% to 110%
Overspeed	120%
Efficiency	90 to 95%
Cooling	Liquid
Overload	150% for 2 mins 200% for 5 secs
Weight Objective	23Kg max
MTBO (Generator)	7500 Hrs
Motor Power	5kW

b) Control and Protection Requirements

The control unit for the generator shall provide the necessary control, protection and regulation of the generator output to ensure continued safe operation of the system. It shall provide interfaces to the aircraft systems through a combination of discrete signals, analogue signals and data bus connections to allow for the safe control and monitoring of the system by the aircrew. The unit shall incorporate PBIT, IBIT and CBIT that checks the health of the unit and generator and provides maintenance data through the data bus system.

As a minimum the control and protection functions shall include:

- Voltage Regulation
- Overvoltage Detection (at least a duplex system using dissimilar techniques)
- Overcurrent Protection
- Short Circuit Protection
- Arc Fault Protection
- Overheat Protection

In addition control and protection of the motor function shall be provided to ensure the safe and satisfactory operation of the generator when powering the gearbox accessories. As a minimum the following functions shall be provided:

- Overcurrent protection (Field)
- Motor Speed control
- Motor Torque Control
- Overspeed Detection

Modelling

Mathematical modelling and simulation tools shall be used from the onset of the design, and throughout the design process, so as to explore system concepts, predict operational behaviour, correct design errors, eliminate prototyping steps and reduce the overall component and system test cycles. These models shall be developed using an electrical simulation tool agreed with by WAL.

Qualification

Qualification activities for the HVDC generator system shall be conducted to enable experimental flight approval of the equipment for fitment on the prototype Tiltrotor NextGen CTR aircraft. Qualification shall consist of both hardware and software verification, taking into consideration RTCA DO-254, RTCA DO-178 and RTCA DO-160G, to show the correct system performance and functionality in accordance with the appropriate system specifications.

Work Packages and Tasks

Tasks		
Ref. No.	***Title - Description***	***Due Date*** [T0+mm]
T0	Conceptual Design Review high-level system requirements to provide a definition of the equipment configuration through detailed system requirements.	T0+3
T1	Preliminary Design Development of the HVDC generator system configuration and support of Preliminary Design Review.	T0+6

Tasks		
Ref. No.	***Title - Description***	***Due Date*** [T0+mm]
T2	System Modeling Definition and development of detailed simulation models and analysis tools to validate specific functions and requirements	T0+20
T3	Detail design Continued design and development of the system leading to CDR when the equipment design is ready for manufacture.	T0+26
T4	Prototype Manufacture & Testing The manufacture and test of a fully representative prototype/rig units.	T0+38
T5	Test Readiness Agreement of qualification test procedures and support to Test Readiness Review for EFA qualification.	T0+44
T6	EFA Qualification EFA qualification testing (environmental and functional qualification of HW, formal SW testing and qualification). Manufacturing of EFA flight-worthy units. Preparation of Qualification Test Reports and Declaration of Design and Performances (DDP) to allow experimental flight trials.	T0+48
T7	Support to aircraft installation Support to integration into the aircraft by WAL, required flight activities and continued airworthiness	T0+66

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date*** [T0+mm]
D.1	Initial System Definition	R	T0+3
D.2	Configuration development and Preliminary Design Review deliverables	R / D	T0+6
D.3	Detailed HW and SW design, Critical Design Review deliverables	R / D	T0+26
D.4	Fully representative rig units provided	D	T0+37
D.5	Technical documentation supporting TRR, Qualification Test Plan and Procedures	R	T0+44
D.6	Qualification Test Reports, EFA DDP	R	T0+48
D.7	EFA shipset and spare units	D	T0+48
D.8	Amended design documents according to flight trials results	R	T0+66

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

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date*** [T0+mm]
M1	System Requirement Review	RM	T0+3
M2	Preliminary Design Review	RM	T0+6
M3	Critical Design Review	RM	T0+26
M4	Test Readiness Review	RM	T0+44
M5	Experimental Flight Approval	R / D	T0+48

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

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

As a general remark, it is highly recommended that the proposed technologies have at least TRL 4 at T0. Moreover, the Applicant(s) shall own the following pedigree and special skills:

- Compliance to SAE AS9100.
- Experience of aeronautic rules, certification processes and quality requirements.
- Experience in design, validation, manufacturing and environmental/functional qualification of airborne equipments, according to RTCA-DO-160, RTCA-DO-178 and RTCA-DO-254 (or other civil or military equivalent standards) for safety critical equipments.
- Familiarity with EMI compatibility issues: capacity to design complex electronic HW in compliance with EMC guidelines, and experience in performing EMC justification analyses and experimental assessments according to RTCA-D0-160, EUROCAE ED-107/ARP-5583, ED-81/ARP-5413 and ED-84/ARP-5412 or equivalent civil or military standards.
- Experience in research, development and manufacturing (or integration) in the following technology fields:
  - Electrical power generation including the requirement to show compliance with the applicable power supply standards.
  - HVDC solid state switching technology.
- Well proven engineering and quality procedures capable to produce the necessary documentation and means of compliance to achieve the “Safety of Flight” with the applicable Airworthiness Authorities (FAA, EASA, etc.).
- Design Organization Approval (DOA) desirable.
- Experience in Safety assessment process according to SAE-ARP-4754 and SAE-ARP-4761 standards, willingness to interact closely with WAL safety specialists in order to produce the necessary outputs (safety and reliability reports and fault trees/analyses).
- Shape, component design and structural analysis using CATIA v5 and NASTRAN, or compatible SW tools.

- Capacity to optimize the HW and SW design, to model mathematically/numerically complex mechatronic systems with suitable simulation tools (Matlab/Simulink, Dymola/Modelica, etc.) and to analyze both simulation and experimental results to ensure that the various required performance goals are met.
- Capacity to repair "in-shop" equipment due to manufacturing deviations.

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

5. Abbreviations

APU	Auxiliary Power Unit
BIT	Built In Test
CDR	Critical Design Review
CBIT	Continuous Built In Test
CTR	Civil Tilt Rotor
CS2	Clean Sky 2
DC	Direct Current
DDP	Declaration of Design and Performance
DMU	Digital Mock Up
DOA	Design Organization Approval
EFA	Experimental Flight Approval
EMC	Electro-Magnetic Compatibility
EMI	Electro-Magnetic Interference
FRC	Fast RotorCraft
GCU	Generator Control Unit
HUMS	Health Usage Monitoring System
HVDC	High Voltage Direct Current
HW	Hardware
IADP	Innovative Aircraft Demonstrator Platform
IBIT	Initiated Built In Test
MTBO	Mean Time Between Overhaul
NDA	Non Disclosure Agreement
NGCTR	Next Generation Civil TiltRotor
PBIT	Power Up Built In Test
PDR	Preliminary Design Review
RPM	Revolutions Per Minute
SRR	System Requirement Review
SW	Software
TBC	To Be Confirmed
TBD	To Be Defined
TRL	Technology Readiness Level
TRR	Test Readiness Review
WAL	Work Area Leader

IV. Power Distribution

Type of action (RIA or IA)	IA		
Programme Area (ref. to SPD)	FRC		
Joint Technical Programme (JTP) Ref. (ref. to Work Package)	WP 1.1 and 1.6		
Indicative Funding Topic Value (in k€)	1500 k€		
Duration of the action (in months)	66 months	**Indicative Start Date[20]**	Q1 2017

Identification	Title
JTI-CS2-2016-CFP03-FRC-01-09	**Power Distribution**
Short description (3 lines)	
Design, development, testing and flight qualification of high power Power Distribution Units (PDUs) for the safe control and protection of the High Voltage Direct Current (HVDC), Low Voltage Direct Current (LVDC) electrical generation system supplies on the Next Generation Civil Tilt Rotor.	

[20] 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 electrical power distribution system. 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 function of any power distribution system within an aircraft is to automatically switch the aircraft electrical power sources, through the primary busbar arrangement, to the electrically powered equipment in a safe and efficient manner. Therefore normally included within this description are primary power distribution units containing high power contactors, secondary power distributions units that could be CB's or SSPC, power conversion equipments and any control of these devices. With the introduction of the more electric aircraft greater emphasis is being placed on this distribution architecture due to the higher power demands, the use of electrical power for more flight critical applications and the more efficient use of the power sources available. This together with the standard requirements of reduced weight, increased reliability and easier maintainability lead to the requirement for a distributed architecture with a more modular approach to power distribution with a greater emphasis on safety criticality.
The aim of the Tiltrotor NextGen CTR is to utilise HVDC supplies for flight critical flight controls as well as more traditional utilities, such as ECS and anti-ice/de-ice systems, and to minimise the amount of conversion required to other voltages, be they AC or DC. As such an innovative electrical power distribution system is required to provide power from source to equipment so to:

- maximise the usage of the power sources using 'smart' power management,
- meet the stringent safety requirements for supplies to flight critical systems,
- perform power conversion where required,
- minimise weight through the use of a distributed architecture,
- improve reliability and reduce maintenance cost.

2. Scope of work

The main objective of this CfP is to design, develop, and manufacture a new electrical power distribution system for the Tiltrotor NextGen CTR. This system has to ensure the safe and efficient distribution of HVDC from the aircraft primary power sources to the respective equipment loads, including flight safety critical loads, together with power conversion of this HVDC to more standard aircraft voltages and the distribution of this power as required. To ensure efficient use of the aircraft power, especially during failure conditions, the power distribution system should be integrated with a new ‘smart’ power management system that can take into account aircraft operating parameters to determine the most desirable system configuration.

The use of HVDC as the primary power source is based on the weight saving benefits that high voltage offers together with the simplification of load conversion. The exact voltage to be used is still under consideration and will be dependent on the loads to be supplied. However with the use of HVDC as the primary power source significant consideration needs to be given to the potential wiring faults that may be experienced and a robust protection mechanism implemented to minimise any damage these failures may cause.

The system shall be designed such that the main system functionalities and performance are guaranteed throughout the whole aircraft flight operation, whilst ensuring adequate safety levels are maintained. Consideration needs to be given to the requirement for civil certification, safety, electrical power supply quality, engine starting power, mission reliability and availability, testability and maintainability. Failures of power supplies to the flight critical components are considered catastrophic and therefore the architecture should ensure a failure rate of less than 10^{-9} for these supplies. This failure rate can be reached by a combination of power distribution architecture and multiple supplies to the equipments and will be continuously reviewed by WAL and the partner during the design of the product. Where new technology is introduced in parts of the system with high criticality, consideration should be given of also using established dissimilar power system functions so as to reduce the criticality of these new functions and allow the flight demonstrator safety of flight (SOF) clearance within the timeline of this call. These established functions however, should not distract from the requirement of proving the new technology can meet certifiable standards.

Another important feature that needs to be considered as part of the power distribution system design is the ability to add future systems and functions as the aircraft concept evolves. As such the main components of the system should have a modular structure to allow for future growth and also to aid in maintainability of the unit by allowing replacing of simple modules rather than whole LRU’s.

It is extremely important that the operational status of the power distribution system is understood during all the flight phases and operational conditions of the aircraft. Therefore the equipment needs to incorporate extensive health monitoring, including PBIT, CBIT and IBIT, that can be used to optimize maintenance actions and failure detection of not only itself but of the equipment connected to it.

Implementation

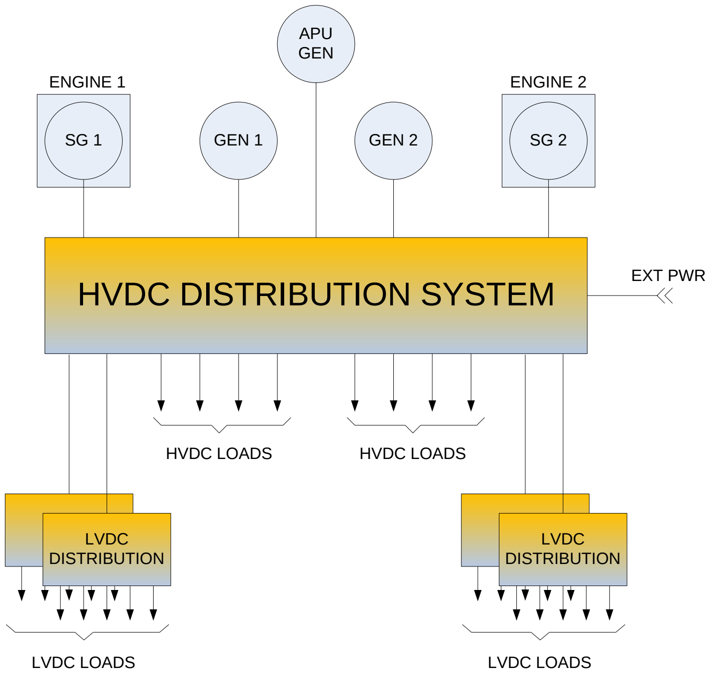


Figure 9 – Electrical Distribution Top Level Architecture

The Distribution System can be considered in two parts:

c) The HVDC distribution system which provides control and protection of the HVDC supplies from the aircraft main power sources (two engine mounted integrated starter generators, two gearbox mounted generators, an APU generator and an external power source) to the applicable aircraft loads,

d) The LVDC distribution system which provides control and protection of the secondary distribution of LVDC to the applicable aircraft loads and incorporates the necessary power conversion from the primary HVDC supply to LVDC.

As stated the HVDC distribution system shall provide an interface between the main aircraft HVDC power sources (two engine mounted starter generators, two gearbox mounted generators, an APU generator and an external power source) and the aircraft flight essential and utility loads. The proposed architecture is to consider each integrated starter generator to be rated at 50kW and each generator to be rated at 90kW, with this being confirmed during the initial concept evaluation stage. The main functions to be incorporated into the HVDC Distribution System with the necessary level of integrity are:

- Distribute HVDC power from the appropriate power sources available during the different aircraft operational conditions to the aircraft HVDC loads within the safety criticality levels applicable.
- Automatically reconfigure the power distribution system during power supply failure conditions ensuring the supplies to the aircraft HVDC loads are maintained to the

appropriate safety criticality level and within the required specification.

- Provide protection of the HVDC distribution system and interconnecting heavy duty cabling (overcurrent, arc fault etc...)
- Provide the necessary control functions, including ‘smart’ load management to ensure the efficient use of the power available.
- Control and protect the application of HVDC power to the ISG’s during engine starting operations.
- Supply status indications, BIT data and HUMS data to the various aircraft systems through a combination of discrete signals, analogue signals and data bus connections.
- Allow the switching of the distributed loads to the HVDC supplies as commanded from the aircraft systems through the data bus and within the constraints of the ‘smart’ load management.

With the advancement in solid state technology and especially the use of Silicon Carbide (SiC), with its higher operating temperatures and lower on resistance, there is an opportunity to utilise solid state switches as the primary switching mechanism within the HVDC distribution unit of the aircraft. This should provide significant benefits in terms of fault isolation, cooling provisions, space envelope, weight and system reliability compared with traditional switching technologies. As such the applicant shall, as part of the initial concept evaluation phase, develop the use of this technology into the HVDC distribution system whilst being cognisant of the necessary safety criticality levels required.

The LVDC distribution system shall provide conversion of the HVDC supplies to the required LVDC level and then distribute these supplies to the respective aircraft loads using solid state power controllers. The LVDC distribution system design needs to be cognisant of the aircraft equipment locations so as to minimise weight through use of multiple distributed LRU’s, whilst still ensuring the required safety requirements for the equipment supplies are maintained. Different architectures shall be explored during the initial concept evaluation phase to decide on the optimum solution. The power convertors shall input the HVDC supply meeting the power supply characteristics of MIL-STD-704F and provide a LVDC supply to the requirements of RTCA DO-160G with isolation between the two supplies. The main functions of the LVDC distribution system shall be to:

- Convert the HVDC supplies provided from the aircraft HVDC buses to LVDC supplies to be distributed to the aircraft equipments.
- Provide protection of the LVDC converter output against overvoltage, overload, short circuit.
- Distribute LVDC power from the converters during the different aircraft operational conditions to the aircraft LVDC loads within the safety criticality levels applicable.
- Automatically reconfigure the power distribution system during power supply and inverter failure conditions ensuring the supplies to the aircraft LVDC loads are maintained to the appropriate safety criticality level and within the required specification.
- Provide protection of the LVDC distribution system and interconnecting cabling (overcurrent, arc fault etc...)
- Provide the necessary control functions to ensure the efficient use of the power available.

- Supply status indications, BIT data and HUMS data to the various aircraft systems through a combination of discrete signals, analogue signals and data bus connections.
- Allow the switching of the distributed loads to the LVDC supplies as commanded from the aircraft systems through the data bus and within the constraints of the 'smart' load management.

Modelling

Mathematical modelling and simulation tools shall be used from the onset of the design, and throughout the design process, so as to explore system concepts, predict operational behaviour, correct design errors, eliminate prototyping steps and reduce the overall component and system test cycles. These models shall be developed using an electrical simulation tool agreed with by WAL.

Qualification

Qualification activities for the electrical power distribution system shall be conducted to enable experimental flight approval of the equipment for fitment on the prototype Tiltrotor NextGen CTR aircraft. Qualification shall consist of both hardware and software verification, taking into consideration RTCA DO-254, RTCA DO-178 and RTCA DO-160G, to show the correct system performance and functionality in accordance with the appropriate system specifications. This shall be achieved through subsystem testing as well as system integration testing.

Work Packages and Tasks

Tasks		
Ref. No.	***Title - Description***	***Due Date*** [T0+mm]
T0	Conceptual Design Review high-level system requirements to provide a definition of the equipment configuration through detailed system requirements.	T0+3
T1	Preliminary Design Development of the distribution system configuration and support of Preliminary Design Review.	T0+6
T2	System Modeling Definition and development of detailed simulation models and analysis tools to validate specific functions and requirements	T0+20
T3	Detail design Continued design and development of the system leading to CDR when the equipment design is from ready for manufacture.	T0+26
T4	Rig Manufacture / Rig Testing The manufacture of fully representative rig units and integration rig facility to allow end to end testing of the system.	T0+38

Tasks		
Ref. No.	***Title - Description***	***Due Date*** [T0+mm]
T5	Test Readiness Agreement of qualification test procedures and support to Test Readiness Review for EFA qualification.	T0+44
T6	EFA Qualification EFA qualification testing (environmental and functional qualification of HW, formal SW testing and qualification). Manufacturing of EFA flight-worthy units. Preparation of Qualification Test Reports and Declaration of Design and Performances (DDP) to allow experimental flight trials.	T0+48
T7	Support to aircraft installation Support to integration into the aircraft by WAL, required flight activities and continued airworthiness	T0+66

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date*** [T0+mm]
D.1	Initial System Definition	R	T0+3
D.2	Configuration development and Preliminary Design Review deliverables	R / D	T0+6
D.3	Detailed HW and SW design, Critical Design Review deliverables	R / D	T0+26
D.4	Fully representative rig units provided	D	T0+37
D.5	Technical documentation supporting TRR, Qualification Test Plan and Procedures	R	T0+44
D.6	Qualification Test Reports, EFA DDP	R	T0+48
D.7	EFA shipset and spare units	D	T0+48
D.8	Amended design documents according to flight trials results	R	T0+66

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

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date*** [T0+mm]
M1	System Requirement Review	RM	T0+3
M2	Preliminary Design Review	RM	T0+6
M3	Critical Design Review	RM	T0+26
M4	Test Readiness Review	RM	T0+44

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date*** [T0+mm]
M5	Experimental Flight Approval	R / D	T0+48

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

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

As a general remark, it is highly recommended that the proposed technologies have at least TRL 4 at T0. Moreover, the Applicant(s) shall own the following pedigree and special skills:

- Compliance to SAE AS9100.
- Experience of aeronautic rules, certification processes and quality requirements.
- Experience in design, validation, manufacturing and environmental/functional qualification of airborne equipments, according to RTCA-DO-160, RTCA-DO-178 and RTCA-DO-254 (or other civil or military equivalent standards) for safety critical equipments.
- Familiarity with EMI compatibility issues: capacity to design complex electronic HW in compliance with EMC guidelines, and experience in performing EMC justification analyses and experimental assessments according to RTCA-D0-160, EUROCAE ED-107/ARP-5583, ED-81/ARP-5413 and ED-84/ARP-5412 or equivalent civil or military standards.
- Experience in research, development and manufacturing (or integration) in the following technology fields:
    - Electrical power generation and distribution including the requirement to show compliance with the applicable power supply standards.
    - HVDC and LVDC switching technology including solid state power controllers.
    - Electrical Power conversion techniques
- Well proven engineering and quality procedures capable to produce the necessary documentation and means of compliance to achieve the "Safety of Flight" with the applicable Airworthiness Authorities (FAA, EASA, etc.).
- Design Organization Approval (DOA) desirable.
- Experience in Safety assessment process according to SAE-ARP-4754 and SAE-ARP-4761 standards, willingness to interact closely with WAL safety specialists in order to produce the necessary outputs (safety and reliability reports and fault trees/analyses).
- Shape, component design and structural analysis using CATIA v5 and NASTRAN, or compatible SW tools.
- Capacity to optimize the HW and SW design, to model mathematically/numerically complex mechatronic systems with suitable simulation tools (Matlab/Simulink, Dymola/Modelica, etc.) and to analyze both simulation and experimental results to ensure that the various required performance goals are met.
- Capacity to repair "in-shop" equipment due to manufacturing deviations.

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

5. Abbreviations

AC	Alternating Current
BIT	Built In Test
CB	Circuit Breaker
CDR	Critical Design Review
CBIT	Continuous Built In Test
CTR	Civil Tilt Rotor
CS2	Clean Sky 2
DAL	Design Assurance Level
DC	Direct Current
DDP	Declaration of Design and Performance
DMU	Digital Mock Up
DOA	Design Organization Approval
ECS	Environmental Control System
EFA	Experimental Flight Approval
EMC	Electro-Magnetic Compatibility
EMI	Electro-Magnetic Interference
FRC	Fast RotorCraft
HUMS	Health Usage Monitoring System
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
IADP	Innovative Aircraft Demonstrator Platform
IBIT	Initiated Built In Test
ISG	Integrated Starter Generator
JU	Joint Undertaking
LRU	Line Replaceable Unit
LVDC	Low Voltage Direct Current
NDA	Non Disclosure Agreement
NGCTR	Next Generation Civil TiltRotor
PBIT	Power Up Built In Test
PDR	Preliminary Design Review
PDU	Power Distribution Unit
SG	Starter Generator
SOF	Safety of Flight
SiC	Silicon Carbide
SRR	System Requirement Review
SSPC	Solid State power Controller
TBC	To Be Confirmed
TBD	To Be Defined
TRL	Technology Readiness Level
TRR	Test Readiness Review
WAL	Work Area Leader

V. Next Generation Fuel Storage System

<table>
<tr><td>Type of action (RIA or IA)</td><td colspan="3">IA</td></tr>
<tr><td>Programme Area (ref. to SPD)</td><td colspan="3">FRC</td></tr>
<tr><td>Joint Technical Programme (JTP) Ref. (ref. to Work Package)</td><td colspan="3">WP 1.5</td></tr>
<tr><td>Indicative Funding Topic Value (in k€)</td><td colspan="3">1000 k€</td></tr>
<tr><td>Duration of the action (in months)</td><td>48</td><td>Indicative Start Date[21]</td><td>Q1 2017</td></tr>
</table>

Identification	Title
JTI-CS2-2016-CFP03-FRC-01-10	**Next Generation Fuel Storage System**

<table>
<tr><td>Short description (3 lines)</td></tr>
<tr><td>The present activity involves the design, development, manufacture, testing and flight qualification of lightweight tank bladders with integrated gauging capability and high performing foams (closed cells) for Next Generation Civil Tilt Rotor.</td></tr>
</table>

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

1. Background

In the framework of Clean Sky 2 FRC IADP, the present Call requires Partner(s) (company or consortium) to develop a fuel storage subsystem for NGCTR.

2. Scope of work

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

In particular the fuel storage subsystem shall be capable of storing fuel and providing a sufficient mechanical resistance against puntcures and impacts avoiding any leaks. A study shall be carried out on the possibility to separate the fuel storage function of the tanks from the mechanical protection it offers.

In order to prevent any kind of static electric discharge, the fuel tank walls shall be of a charge-dissipative type avoiding the accumulation of static electrical charges.

The fuel tank shall be flexibile enough to be folded allowing it to be installed on the aircraft.

The use of low weight/high resistance synthetic multilayer fabrics or thermoplastic material shall be considered.

A study to add the fuel gauging capability to fuel tanks itself shall be carried out. The gauging capability shall not add a fuel ignition source. The fuel level or quantity information, provided by the “gauging feature“ of the tank, shall be interfaced to the avionics via a digital data bus.

A study to separate the fuel free surface from the empty space into each tank using a membrane shall be carried out. This membrane shall seal the wet side of the tank from its dry side: after fuel refill the wet volume of the tank defined by the membrane shall be the maximum allowable while, when the tank is empty, the dry volume shall be the maximum allowable. The dry volume shall be designed to avoid the generation of an explosive air-fuel mixture.

The internal tank wall shall withstand against corrosive action of antifugii and anti-ice fuel additives and shall be compatible with the most of the jet fuel commercially available (including also bio-fuel). The external fabric of tank shall be compatible with aeronautic sealants and glues and shall provide also a resistance against high temperature that could be induced by failures of other near systems.

The use of hardware for the tank installation (e.g.: pump flange connection, interconnections, structural attachments, access door interface, etc…) shall be minimized and designed to reduce to the minimum the installation and maintenance burden and skill requirements (foolproof design).

If necessary, each tanks shall provide means to avoid damage due to high sloshing induced load.

The fuel storage subsystem shall be ETSO-C80 and CS29.952 a) compliant.

A study for a self seling version of fuel tanks shall be carried out in parallel to the system development phase.

Closed cell, low weight, high stiffness foams shall be designed, possibly adopting innovative materials, in order to protect the fuel tank into the fuel system installation while maintaining the tank shape.

The foam shall be compatible with aeronautic sealants/glues and shall provide also a resistance against high temperature that could be induced by failures of other systems.

The foam shall not modify its crushing characterisitcs (e.g. its stiffness) with time, with temperature, with wetted surfaced and after cyclic load application.

The foams shall withstand several installation cycle of the storage system without changing their shape and characteristics.

The foams shall withstand against corrosive action of antifugii and anti-ice fuel additives and shall be compatible with the most of the jet fuel available (including also bio-fuel).

At the end of the design and development phase, all the evidences necessary to achieve system flightworthiness qualification shall be provided to AW, together with a production shipset and spare part for flight test activity on NGCTR.

The Partner shall guarantee consumable availability and technical support for the entire NGCTR flight test activity following the full qualification milestone completion.

Tasks		
Ref. No.	***Title – Description***	***Due Date*** [T0+mm]
T01	System Definition[(1)]	T0
T02	Trade Off Study results	T0 + 08
T03	Selection of Technology	T0 + 14
T04	Delivery of Design Documentation	T0 + 22
T05	Study for self sealing tank version	T0 + 28

Tasks		
T06	End of Testing Activity for EFA	T0 + 30
T07	Aircraft Qualification Support	T0 + 48

(1): High-level System Requirements will be provided to the selected Partner(s), following the signature of dedicated NDA or equivalent commitment, as part of the techincal discussions between the Partner(s) and AW that will take place after the selection phase (T0).

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date*** [T0 + mm]
D01	Trade Studies Results Report	REPORT	T0 + 08
D02	Draft Fuel Ignition Source Analysis/Assessment	REPORT	T0 + 14
D04	3D models and layout drawing	CATIA FILES	T0 + 14
D05	Qualification program plan (QPP)	REPORT	T0 + 14
D06	Development test plan (DP)	REPORT	T0 + 14
D07	Interface Definition Documents	REPORT and CATIA FILES	T0 + 14
D08	Reliability and FMEA	REPORT	T0 + 22
D09	Failure Modes, Effect and Criticality Analysis (FMECA)	REPORT	T0 + 22
D10	Safety/Hazard Analysis	REPORT	T0 + 22
D11	Acceptance Test Procedures (ATP)	REPORT	T0 + 22
D12	Qualification Test Procedures (QTP)	REPORT	T0 + 22
D13	Qualification by Similarity and Analysis (EFA)	REPORT	T0 + 22
D14	Production and Spare Unit, and relevant Data Conformity Documentation	HARDWARE and REPORT	T0 + 30
D15	Instruction for Continued Airworthiness	MANUAL	T0 + 30
D16	Qualification by Similarity and Analysis (QSAR)	REPORT	T0 + 40
D17	Acceptance and Qualification Test Reports	REPORT	T0 + 40

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date*** [T0 + mm]
M01	Kick-off meeting	DESIGN REVIEW	T0
M02	System Concept Review	DESIGN REVIEW	T0 + 08
M03	Preliminary Design Review	DESIGN REVIEW	T0 + 14
M04	Development unit ready to development tests	HARDWARE	T0 + 20

Milestones (when appropriate)			
M05	Critical Design Review	DESIGN REVIEW	T0 + 24
M06	Equipment Test Readiness Review	DESIGN REVIEW	T0 + 24
M07	First Article Inspection	DOCUMENT	T0 + 30
M08	Aircraft Test Readiness Review	DESIGN REVIEW	T0 + 30
M09	Production unit delivered to AW for flight tests	HARDWARE	T0 + 30
M10	Qualification Closure	DOCUMENT	T0 + 48

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

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

- ✓ Compliance to SAE AS9100.
- ✓ Experience of aeronautic rules, certification processes and quality requirements.
- ✓ Experience in design, validation, manufacturing and environmental/functional qualification of airborne equipments for fuel systems tanks according to RTCA-DO-160
- ✓ Experience in the field of texile fiber (either natural or syntetic) production
- ✓ Experience in research, development and manufacturing in the following technology fields:
  - Conventional fuel system tanks development for aircraft, helicopter and tiltrotors
  - Design of components minimizing ignition hazard in explosive environment
- ✓ Well proven engineering and quality procedures capable to produce the necessary documentation and means of compliance to achieve the "Safety of Flight" with the applicable Airworthiness Authorities (FAA, EASA, etc.).
- ✓ Design Organization Approval (DOA) desirable.
- ✓ Experience in Safety assessment process according to SAE-ARP-4754 and SAE-ARP-4761 standards, willingness to interact closely with WAL safety specialists in order to produce the necessary outputs (safety and reliability reports and fault trees/analyses).
- ✓ Shape, component design and structural analysis using CATIA v5 r22, NASTRAN, Matlab or equivalent softwares.
- ✓ Capacity to optimize the HW and SW design and to analyze both simulation and experimental results to ensure that the various required performance goals are met.
- ✓ Capacity to repair "in-shop" equipment due to manufacturing deviations.

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

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

Type of action (RIA or IA)	IA		
Programme Area	FRC		
Joint Technical Programme (JTP) Ref.	WP 2.2		
Indicative Funding Topic Value (in k€)	1500 K€		
Duration of the action (in Months)	44 months	**Indicative Start Date**[22]	Q1 2017

Identification	Title
JTI-CS2-2016-CFP03-FRC-02-09	**Light weight, impact resistant, canopy for fast compound rotorcraft**
Short description	
A canopy structure has to be developed and manufactured for the Fast Rotorcraft (FRC). It has to comply with the regulations according to CS 29 and has to include features for installed equipment e.g. radar, FLIR, Cable cutter etc. Special care has to put on low aerodynamic drag assured by chosen manufacturing process and integration to the fuselage, weight, as well as bird strike capability.	

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

1. Background

The Fast Rotorcraft Project (FRC) aims at demonstrating that the compound rotorcraft configuration implementing and combining cutting-edge technologies, as from the current Clean Sky Programme, opens up to new mobility roles that neither conventional helicopters nor fixed wing aircraft can currently cover in a sustainable way, for both the operators and the industry.
The project will ultimately substantiate the possibility to combine in an advanced rotorcraft the high cruise speed, low fuel consumption and gas emission, low community noise impact, and productivity for operators. A large scale flightworthy demonstrator embodying the new European compound rotorcraft architecture will be designed, integrated and flight tested.
In addition to the complex vehicle configurations, Integrated Technology Demonstrators (ITDs) will accommodate the main relevant technology streams for all air vehicle applications. They allow the maturing of verified and validated technologies from their basic levels to the integration of entire functional systems. They have the ability to cover quite a wide range of technology readiness levels.

2. Scope of work

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

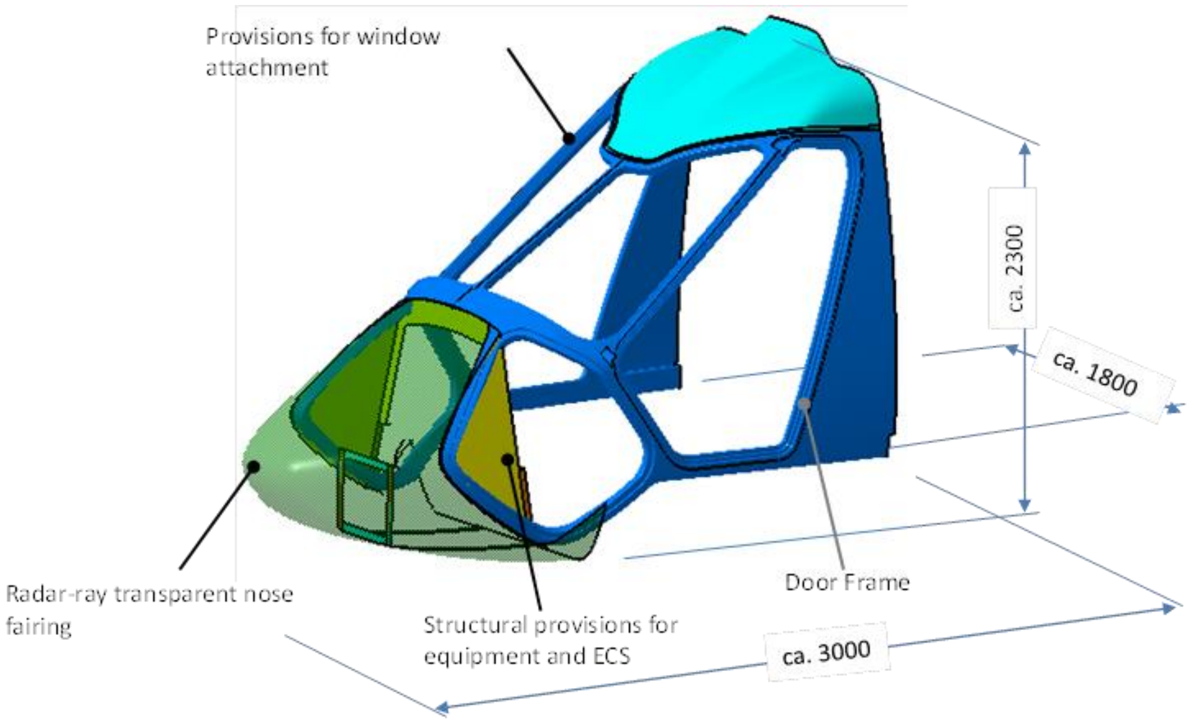
Tasks		
Ref. No.	***Title - Description***	***Due Date***
T1	Development, layout, design and certification of the **Canopy** for a High Speed H/C. (Structural architecture and loft delivered by TM) Features to be included: • Minimum impact on overall drag by optimized manufacturing quality e.g. surface quality, min. gap sizes etc. • Light weight design, partly hollow structure (max. weight < 60 kg) • Provisions for window attachment • Provisions for Door attachment and sealing • Optimized for Pilot's view capability • Structural provisions for equipment and ECS • Radar-ray transparent nose fairing • Maintenance openings • Provisions for extendable/retractable equipment • EMC/bonding and direct lightning effects	T + 6

Tasks		
Ref. No.	***Title - Description***	***Due Date***
	• Bird strike • Inner liner The development has to be done in close cooperation with the Topic Manager and other core partners and partners contributing to Canopy interfaces. The task includes all relevant tooling.	
T2	Manufacturing of the Canopy	T + 20
T3	Acceptance testing of the Canopy in order to demonstrate the required characteristics	T + 21
T4	Delivery of flightworthy canopy	T + 22
T5	Start support to final assembly	T + 22
T6	Provide Contribution to obtain permit to flight documentation for the Canopy (final contribution)	T + 24
T7	Contributing to flight test campaign if needed, cost are to be considered by partner as risk mitigation	T + 50

General remarks:

- The architecture of the Canopy will be done in close cooperation with the Topic Manager.
- The development of the Canopy (shape, dimensions, interfaces, material selection etc) has to be done in close cooperation with the Topic Manager.
- Minimum impact on drag and minimum weight are the main conditions. The partner willl demonstrate to the topic manager that design is done in accordance with the best compromise in term of weight, cost (for serail production part) and drag.
  This can be achieved by optimized combination of materials (eg hybrid concept)
- The door-frames are part of the canopy and must be designed and integrated in close cooperation with the partner responsible for the doors.
- The window frames must be designed in close cooperation with the partner responsible for the windows. Attention has to be put on CS29 requirement for bird strike. This can be achieved by the use of high ductile materials
- The substantiation documentations have to be done according the requirements of the Topic Manager. A harmonization process of the terms of conditions will take place at start of the project (e.g. tools/methods to be used).
- Certification basis is CS29

Sketches & Dimensions



Canopy (draft)

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

Functional Characteristics

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

Note: the transparency and cockpit doors will be provided by another partner selected by other calls.

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

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

3. Major deliverables/ Milestones and schedule (estimate)

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

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

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

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

- Providing material data which are required to achieve a "Permit to Fly";
- Using material, processes, tools, calculation tools etc. which are commonly accepted in the aeronautic industry and certification authorities;
- 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;
- Ensure TRL level 4 is reached for each system/technology upon project start (Q2 2016). Should this condition not be met, the Partner has to provide a mitigation plan enabling to reach the target of TRL 6 at the end of demonstration.

Weight:

The target is obtained the lowest weight as possible for the proposed component compliant with technical requirements and compatible with a serial aeronautical production.
The applicant(s) shall provide an estimated maximum weight of its proposed component. This value will be updated before T0 regarding the design data available at this time, the difference with the weight provided with the offer shall be substantiated and the new weight figure will have to be agreed with the Topic Manager.
For the PDR, the Partner shall a detailed weight breakdown of the component in accordance with the technology, the technical requirement and the interfaces agreed with the leader. The difference with the weight agreed at T0 will be substantiated and submitted to the agreement of the Topic Manager.
For the CDR, the Partner shall provide an update of the weight breakdown with a substantiation of the difference with PDR version. If an update of the overall weight is necessary, it will be submitted to the agreement of the Topic Manager.
The components for the flying demo will be delivered with a weight record sheet; deviation with the maximum weight agreed during CDR will be substantiated.
At the end of the contract, the Partner shall provide a weight estimation of the component for a production part in accordance with the lessons learned during the development.

Recurring cost estimation:
The target is to obtain the optimum between the level of performances of the fast rotorcraft and the cost of the potential product.
For the PDR, the Partner will provide an estimation of the recurring cost of the component on the basis of the assumptions given by the Topic Manager. An up-date will be provided for CDR and at the end of the demonstration phase.

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

- CATIA V5 R21
- VPM
- Windchill

The Topic manager will provide interface drawings and 3D model loft in CATIA V5 R21.
The Partner will provide detailed 3D models for digital mock-up in CATIA V5 R21 and he will support the Topic Manager for the interface definition.
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

<u>Abbreviations</u>: (M) for Mandatory; (A) for Appreciated (with respect to the chosen manufacturing process)

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

Material and Processes

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

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

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

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

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

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

Certification:

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

VII. Design and Realization of equipped engine compartments including cowling for a fast compound rotorcraft

Type of action (RIA or IA)	IA		
Programme Area	FRC		
Joint Technical Programme (JTP) Ref.	WP 2.7		
Indicative Funding Topic Value (in k€)	1250 K€		
Duration of the action (in Months)	42 months	Indicative Start Date[23]	Q1 2017

Identification	Title
JTI-CS2-2016-CFP03-FRC-02-11	**Design and Realization of equipped engine compartments including cowling for a fast compound rotorcraft**
Short description	
The aim of this Call for Proposals is to develop and manufacture the main elements constituting the engine compartments of the High Speed Rotorcraft (Cowlings, Air Intake, Engine Bay Ventilation with exhaust ejector). Activities of project management, engineering, manufacturing and tests have then to be performed by the Partner.	

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

1. Background

The final goal of the "Low Impact, Fast & Efficient RotorCraft (LifeRCraft)" demonstration program is to mature the compound rotorcraft configuration and pave the way for the development of future products fulfilling expectations in terms of door-to-door mobility, protection of the environment and citizens' wellbeing better than conventional helicopters.

To achieve the expected performances of the aircraft, a low drag and low penalty design has to be considered. As in any conventional helicopter, the engines are installed in the upper deck ; mass air flow provided thanks to the air intake and engine hot gazes exhausted through the ejector. In addition to the optimized definition of such components, it is of major importance to minimize the weight penalty and the recurring cost. The present Call for Proposals is devoted to the development and the manufacturing of the Cowlings, Air Intakes and Ejectors.

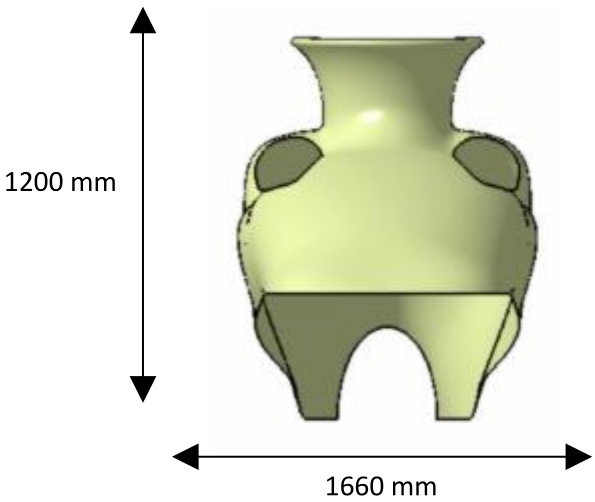
2. Scope of work

The aim of this Call for Proposals is to develop and manufacture the main elements constituting the engine compartments and other upper deck compartments of the High Speed Rotorcraft (Cowlings, Air Intake, Ejector …). Activities of project management, engineering, manufacturing and tests have then to be performed by the Partner.

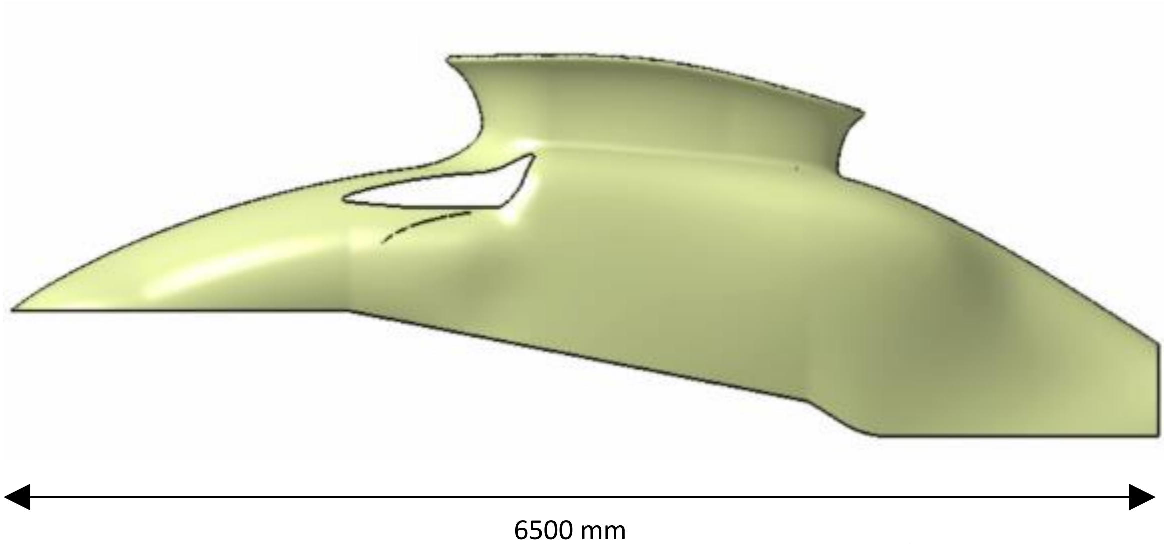
Tasks		
Ref. No.	***Title – Description***	***Due Date***
Task 1.0	Inputs Delivery by the Topic Manager	T0
Task 1.1	General Design and Detailed Design of Upper Cowlings for the LifeRCraft Demonstrator	T0+12
Task 1.2	General Design and Detailed design of the Air Intake and Ventilation ducts for the LifeRCraft Demonstrator	T0+12
Task 1.3	General Design and Detailed Design and Flightworthiness substantiation of the ejector for the LifeRCraft Demonstrator	T0+12
Task 1.4	Manufacturing and quality insurance of Upper Cowlings	TO+18
Task 1.5	Manufacturing and quality insurance of Air Intake & ventilation ducts	T0+18
Task 1.6	Manufacturing and quality insurance of Ejector	T0+18
Task 1.7	Airworthiness and compliance substantiation of the Upper Cowlings including Tests	T0+27
Task 1.8	Airworthiness and compliance substantiation of the Air Intake & ventilation ducts including Tests	T0+27
Task 1.9	Airworthiness and compliance substantiation of the Ejector including Tests	T0+27

General remarks:

- Constitutive elements of the upper deck have to be designed, with the target to to fulfil all qualification requirements according to CS29 and Special Conditions, if applicable. This includes a full workable cowling, including a heat protection for specific hot areas. The partner has to provide substantiation in order to get with the demonstrator manufactured part a demonstrator flight clearance (the full certification compliance substantiation is not required for the demonstrator): it should include description of the design and stress
- The substantiation documentations have to be done according the requirements of the Topic Manager. A harmonization process of the terms of conditions will take place at start of the project (e.g. tools to be used).
- Rough dimension of the cowlings are described in the following drawings:

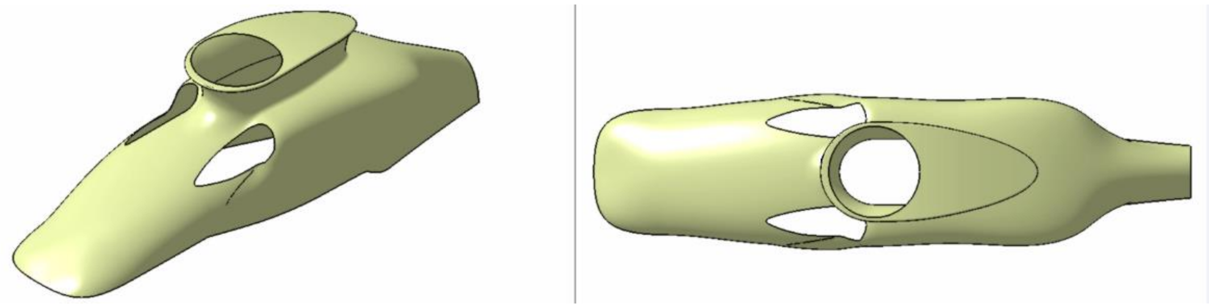


Cowlings : Front View Example



Cowlings : Side View Example : closed

These dimension are a preliminary information, final data will be given at T0.



-
- The cowling will be split in several parts, some of them to be open or movable for periodic maintenance.

Cowlings : Global aspect

- The solution established by the Partner can involve a wide range of technologies from classical metallic parts, through composite parts, up to any innovative material and associated process.The selection of the materials insuring the required fire-proof resistance will be done in close collaboration between the Partner and the Topic Manager.

<u>Task 1.0</u>: Inputs Delivery by the Topic Manager

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

- CAD model files of the A/C (CATIA files) including duct internal geometry and space allocation,
- Structural loads and thermal conditions,
- Functional Specification.

<u>Task 1.</u>1: General Design and Detailed Design of Cowlings for the LifeRCraft Demonstrator

With the preliminary Design, Specification & Requirements provided by the Topic Manager as inputs, the Partner is asked to realize the detailed design and detailed definition of the cowlings of the aircraft. Such Design must pay peculiar attention on :

- Weight : Light weight design
- Cost : Low recurring cost
- Shape : High shape fidelity (low deviation, low surface waviness, maximum flushness between parts and controlled step and gap) with respect to the loft lines provided by the Topic Manager

This task must also take into account several considerations, such as :

- Computational Structural Mechanics (CSM) calculations to ensure compliance with specified structural loads and temperature
- Easy and fast assembly, installation & removal in accordance to Design Specification
- Improved maintenance & inspections capability in accordance to Design Specification
- Reliable and improved Opening and Locking devices
- Compliance with existing interfaces

This task has to be performed in close cooperation with the Topic Manager.

Task 1.2: General Design and Detailed design of the Air Intake and Ventilation ducts for the LifeRCraft Demonstrator

With the preliminary Design, Specification & Requirements provided by the Topic Manager as inputs, the Partner is asked to realize the design and detailed definition of the Air Intake and Ventilation ducts (ventilation for equipments) of the aircraft. Such Design must pay peculiar attention on :
- Weight : Light weight design
- Cost : Low recurring cost
- Shape : High shape fidelity (low deviation, low surface waviness, maximum flushness between parts and controlled step and gap) with respect to the loft lines and the other design requirements (quality of surface, gap requirement between ducts, thermal conductivity of the wall, protection screen…) provided by the Topic Manager

This task must also take into account several considerations, such as :
- Computational Structural Mechanics (CSM) calculations to ensure compliance with specified structural loads and temperature
- Easy and fast assembly, installation & removal in accordance to Design Specification
- Improved maintenance & inspections capability in accordance to Design Specification

Optional: Computational Flow Dynamic calculations to ensure compliance with specified air flow requirements

This task has to be performed in close cooperation with the Topic Manager.

Task 1.3: General Design and Detailed Design of the ejector for the LifeRCraft Demonstrator

With the preliminary Design, Specification & Requirements provided by the Topic Manager as inputs, the Partner is asked to realize the design and detailed definition of the engine ejector of the aircraft. Such Design must pay peculiar attention on :
- Weight : Light weight design
- Cost : Low recurring cost
- Shape : High shape fidelity (low deviation, low surface waviness, maximum flushness between parts and controlled step and gap) with respect to the loft lines provided by the Topic Manager

This task must also take into account several considerations, such as :
- Computational Structural Mechanics (CSM) calculations to ensure compliance with specified structural loads and temperature
- Thermo-mechanic analysis to ensure compliance with specified requirements
- Easy and fast assembly, installation & removal in accordance to Design Specification
- Improved maintenance & inspections capability in accordance to Design Specification

This task has to be performed in close cooperation with the Topic Manager.

Task 1.4: Manufacturing and quality insurance of Cowlings

The Partner has to manufacture the cowlings with a proven maturity technology in order to be able to safely reach the required technology readiness for the flying demonstrator. The cowlings could be made of several intercheangable parts. The parts have to be delivered with the all documentation necessary to prove compliance with the design within the specified tolerance margins.

Task 1.5: Manufacturing and quality insurance of Air Intake & ventilation ducts

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The Partner has to manufacture the Air Intake & ventilation ducts with a proven maturity technology in order to be able to safely reach the required technology readiness for the flying demonstrator. Special attention has to be paid on steps and gaps due to production scatters. The parts have to be delivered with the all documentation necessary to prove compliance with the design within the specified tolerance margins.

Task 1.6: Manufacturing and quality insurance of Ejectors

The Partner has to manufacture the ejector with a proven maturity technology in order to be able to safely reach the required technology readiness for the flying demonstrator. The parts have to be delivered with the all documentation necessary to prove compliance with the design within the specified tolerance margins.

Task 1.7: Airworthiness and compliance substantiation of the Cowlings

Manufactured parts must meet airworthiness criteria as needed by the Topic Manager to substantiate the flight demonstrator airworthiness according to Permit to Fly requirements. Particulary, a part of cowlings have to be substantiated as « fire-proofed ». They must also meet acceptance criteria specified in the Topic Leader functionnal specification. Flightworthiness and functionality could be demonstrated through dedicated tests (test on specimens or sample parts, , Scan 3D validation, First Article Inspection, etc.)

Task 1.8: Airworthiness and compliance substantiation of the Air Intake & ventilation ducts

Manufactured parts must meet airworthiness criteria as needed by the Topic Manager to substantiate the flight demonstrator airworthiness according to Permit to Fly requirements. Particulary, air intakes have to be substantiated as « fire-proofed ». They must also meet acceptance criteria specified in the Topic Leader functionnal specification. Flightworthiness and functionality could be demonstrated through dedicated tests (test on specimens or sample parts, validation of steps and gaps due to production scatters, Scan 3D validation, First Article Inspection …)

Task 1.9: Airworthiness and compliance substantiation of the Ejector

Manufactured parts must meet airworthiness criteria as needed by the Topic Manager to substantiate the flight demonstrator airworthiness according to Permit to Fly requirements. Particulary, ejectors have to be substantiated as « fire-proofed » and have to withstand to impigment of engine exhaust gases. They must also meet acceptance criteria specified in the Topic Leader functionnal specification. Flightworthiness and functionality could be demonstrated through dedicated tests (test on specimens or sample parts, validation of steps and gaps due to production scatters, Scan 3D validation, First Article Inspection …)

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
L1.1	Concept for Upper Cowlings (material, structure, locking mechanism, modularity ...)	DOC	T0+6
L1.2	Concept for Air Intake and Ventilation Ducts	DOC	T0+6
L1.3	Concept for ejectors (material, structure ...)	DOC	T0+6
L2.1	Detailed Drawings for Upper Cowlings, Ait Intakes, Ventilation Ducts and Ejectors	DOC	T0+12
L3.1	Upper Cowlings for Mock-up/tests	HW	T0+16
L3.2	Air Intake and Ventilation Ducts for Mock-up/tests	HW	T0+16
L3.3	Ejector for Mock-up/tests	HW	T0+16
L4.1	Upper Cowlings for Prototype and Flight Tests	HW	T0+24
L4.2	Air Intake and Ventilation Ducts for Prototype and Flight Tests	HW	T0+24
L4.3	Ejector for Prototype and Flight Tests	HW	T0+24
L4.4	Airworthiness and Compliance substantiation for Upper Cowlings	HW	T0+27

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
L4.5	Airworthiness and Compliance substantiation for Air Intake and Ventilation Ducts	HW	T0+27
L4.6	Airworthiness and Compliance substantiation for Ejector	HW	T0+27
L5.1	Report about contribution to flight test	DOC	T0+42

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Preliminary Design Review	MS	TO+6
M2	Critical Design Review	MS	T0+12
M3	Acceptance Review	MS	T0+16
M4	Flight Readiness Review	MS	T0+24
M5	First flight test campaign completed with Partner support	MS	T0+36

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

The Topic Manager is the responsible in front of the airworthiness agency, and it is therefore mandatory for the Partner to support the Topic Manager with respect to all “permit to fly “ related activities in relation with the cowlings, air intake (and ventilation ducts), ejector and engine firewall. Therefore the Partner has to provide all documentation necessary to achieve “Permit to Fly” and take action allowing this goal to be reached:

- Providing material data which are required to achieve a “Permit to Fly”;
- Using material, processes, tools, calculation tools etc. which are commonly accepted in the aeronautic industry and certification authorities;
- Facilitating harmonization of calculation processes/tools with the Topic Manager;
- Acting interactive with the Topic Manager at any state of work;
- Giving access to the production and test sites;
- Performing the updates of documentation in case of in-sufficient documentation for authorities;
- Checking TRL level 4 is reached for each system/technology upon project start (Q1 2017). Should this condition not be met, the Partner has to provide a mitigation plan enabling to reach the target of TRL 6 at the end of demonstration.

Special Skills

The Partner should have significant experience in design, manufacturing and testing of metalic and composite airframes.

- Design, analysis and configuration management tools of the aeronautical industry (i.e. CATIA v5 release 21, NASTRAN, VPM, Windchill).
- Competence in management of complex projects of research and manufacturing technologies.
- Experience with TRL Reviews or equivalent technology readiness assessment techniques in research and manufacturing projects for aeronautical industry.
- Proven experience in collaborating with reference aeronautical companies with industrial air vehicle developments with "in – flight" components experience.
- Capacity to support documentation and means of compliance to achieve experimental prototype "Permit to Fly" with Airworthiness Authorities (i.e. EASA, FAA and any others which may apply).
- Capacity to specify material and structural tests along the design and manufacturing phases of aeronautical components, including heat protection technology
- Capacity to perform structural and functional tests of aeronautical components: test preparation and analysis of results.
- Capacity to repair/rework "in-shop" components due to manufacturing deviations.
- Capacity of performing Life Cycle Analysis (LCA) and Life Cycle Cost Analysis (LCCA) of materials and structures.
- Capacity of evaluating design solutions and results along the project with respect to Eco-design rules and requirements.
    - Design Organization Approval (DOA).
    - Product Organization Approvals (POA).
    - Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004)
- Qualification as Material and Ground Testing Laboratory of reference aeronautical companies (i.e. ISO 17025 and Nadcap).
- Technologies for metallic and composite material manufacturing.
- Mechanical processes, regarding assembly of upper cowlings, air intakes, ejector and firewall on the aircraft upper deck.

Material and Processes

In order to reach the main goals of the project, two major aspects have to be considered for materials and processes, namely: maturity and safety for the project. Because of the ambitious plan to develop a flying prototype in a short time frame, the manufacturing technology of the partner must be on a high maturity level (TRL4) in order to be able to safely reach the required technology readiness for the flying demonstrator. To secure this condition, the Partner will have to demonstrate the technology readiness for his proposed materials and process and manufacturing technology with a TRL review, to be held together with Topic Manager.

Furthermore, since the schedule of the project and the budgetary framework don't allow for larger unanticipated changes during the project, it is required that at the start of activities the partner demonstrates his capability to develop and manufacture the required items with a baseline technology which will be a back-up solution in case the new technology to be introduced proves to be overly challenging.
This back-up plan, which shall secure the meeting of the project goals, shall also be agreed between the Topic Manager and the Partner within half a year after the start of the activities and approved by the JU.
Furthermore the M&P activities in the project shall support the safe inclusion of the partner's technology into the complete H/C.

Certification

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

Weight

The target is to obtain the lowest weight as possible for the proposed component compliant with technical requirements and compatible with a serial aeronautical production. The applicant(s) shall provide an estimated maximum weight of its proposed component. This value will be updated before T0 regarding the design data available at this time, the difference with the weight provided with the offer shall be substantiated and the new weight figure will have to be agreed with the Topic Manager.

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

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

The components for the flying demonstrator will be delivered with a weight record sheet, deviation with the maximum weight agreed during CDR will be substantiated. At the end of the contract, the Partner shall provide a weight estimation of the component for a production part in accordance with the lessons learned during the development.

Recurring cost estimation

The target is to obtain the optimum between the level of performances of the fast rotorcraft and the cost of the potential product.
For the PDR, the Partner will provide an estimation of the recurring cost of the component on the basis of the assumptions given by the Topic Manager. An up-date will be provided for CDR and at the end of the demonstration phase.

Data management

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

- CATIA V5 R21
- VPM
- Windchill

The Topic Manager will provide interface drawings and 3D loft in CATIA V5 R21.
The Partner will provide detailed 3D models for digital mock-up in CATIA V5 R21 and he will support the Topic Manager for the interface definition.
The data necessary for configuration management have to be provided in a format compatible with VPM and Windchill tool.

Eco-design

The capacity of performing Life Cycle Analysis (LCA) to define environmental impact of technologies (energy, VOC, waste, etc.). This approach will be integrated during design & manufacturing phases. The Topic Manager will be able support LCA approach (Methodologies training or pilot cases). Capacity to monitor and decrease the use of hazardous substances e.g. compliance with REACh regulation.

VIII. Advanced Health Monitoring System for next generation materials

Type of action (RIA or IA)	IA		
Programme Area	FRC		
Joint Technical Programme (JTP) Ref.	WP 2.6.11		
Indicative Funding Topic Value (in k€)	500 K€		
Duration of the action (in Months)	24 months	**Indicative Start Date**[24]	Q1 2017

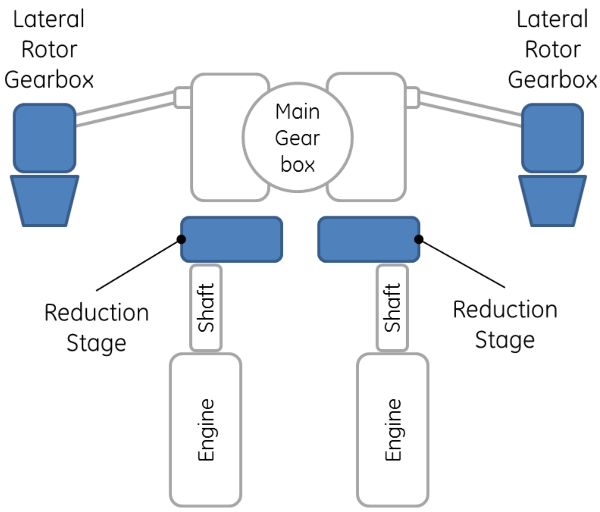
Identification	**Title**
JTI-CS2-2016-CFP03-FRC-02-15	**Advanced Health Monitoring System for next generation materials**
Short description	
The aim of this Call for Partner is to define an advanced Health Monitoring System (HMS) for the Lateral Rotor Gearboxes and Engine to Main Gearbox reduction stages, developed for the Compound Rotorcraft Demonstrator in the frame of IADP FRC. The activities to be performed range from the identification of monitoring means and suitable sensing technologies, the development of the detection logic and algorithms, up to verification on test rigs and on gearbox module development test rig.	

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

1. Background

Avio Aero (Topic Manager) is developing, in the frame of Mobility Discovery project, gearboxes that are part of the mechanical drive system for the innovative architecture of the LifeRCraft full scale demonstrator, a fast compound rotorcraft.
The Mobility Discovery gearboxes are:

- Two Lateral Rotor Gearboxes (Left and Right), installed at the tip of the rotorcraft wings and transmitting mechanical power from the lateral shafts to the rotors. These gearboxes are mainly constituted of bevel gears, bearings, housings, an independent lubrication and cooling system (with pump, heat exchanger and other accessories and monitoring sensors).
- Two reduction stages at the inlet of the Main Gearbox (one for the left engine and one for the right one, practically with the same design). These stages are mainly constituted of helical gears, bearings, housings and part of lubrication system.



Safety and Reliability are two main CTQs for the Mobility Discovery project; an effective Health Monitoring System (HMS) is a key element to meet a high level of Safety and Reliability for the entire system, through rapid and reliable detection and diagnosis (isolation) of gearbox faults. Such HMS also enables optimised on-condition maintenance, thus reducing the Life Cycle Cost of the drive system.
Affordability can also be positively impacted by an advanced HMS that is expected to require a reduced number of sensors with respect to more conventional ones.

Typical HMS for rotorcraft gearboxes includes systems for monitoring Oil Debris and Vibrations, tailored to the gearbox architectures and failure modes, and the materials used.
The gearboxes of Mobility Discovery will introduce next generation materials and technologies (e.g. ceramics), and has to meet at the same time challenging Safety and Reliability requirements: an advanced HMS is considered an enabling factor to meet these targets.

The HMS will need to allow the monitoring of wear and failures mainly of the rotating gearbox components: gears and bearings.
For the Mobility Discovery bearings it is foreseen the use of innovative materials such as ceramics for the rolling elements. The HMS will need to be developed and validated taking this into account (i.e. no metallic debris released from the rolling elements, but only from the bearing races).
An innovative technology that can be considered for vibration monitoring, is the use of microphones instead of the more conventional accelerometers. Expected benefits are:

- a reduced number microphones with respect to a high number of accelerometers, thus positively impacting the engine affordability
- an earlier detection of possible failure

The TRL of the proposed HMS technologies will be assessed throughout the project. If TRL will be deemed adequate to not introduce risks to the demonstrator programme and implementation will still be possible, the opportunity to further mature such technologies through flight test on the full scale demonstrator will be evaluated. Relevant costs for such implementation are out of the scope of this call.

The requirements and CTQs for the advanced HMS will be defined by the Topic Manager upfront the start of this Call for Partners, and will be an input for it.

2. Scope of work

The possible tasks structure is the following:

WP 1 Identification of monitoring means suitable for next generation materials (e.g. ceramics) and failure mechanisms
Starting from the requirements and the CTQs that will be defined by Avio Aero as an input to the CfP, together with the description of the gearboxes architecture, materials and expected failure modes, this task will identify the monitoring means suitable to detect wear and faults.

WP 2 Available technology assessment
Based on the monitoring means identified in the previous task, this task will focus on the assessment and ranking of available (i.e. off the shelf) technologies and analysis techniques suitable for HMS (including sensors, signals transmission and processing).

WP 3 Development of detection logic and algorithms, possibly combining different signals
The detection logic and the relevant algorithms will be developed under this task. The possibility of combining different signals (e.g. oil debris with vibration signals) to reach improved monitoring performances will have to be assessed.

WP 4 Evaluation tests on dedicated rigs

Downselected technologis shall be validated through rig testing, to verify the effectiveness and reliability of HMS in detecting the typical gearbox components faults (high detection rate of real faults and low rates of false alarms and missed detections).
It is expected that the single applicant or the consortium make use of available rig. During project evaluation, the option to use Topic Manager assets might also be considered.

WP 5 Data acquisition during gearbox testing and assessment
The advanced HMS will be implemented on the gearbox modules during the development rig testing that will be performed by the Topic Manager, to acquire and analise data in the real system environment. In addition to data acquisition and analysis, support is expected from the applicant during the test campaign (e.g. trubleshooting of HMS, fault fixing)

Tasks		
Ref. No.	***Title - Description***	***Due Date***
WP 1	Monitoring means identification	T_0 + 3 months
WP 2	Available technology assessment	T_0 + 5 months
WP 3	Development of detection logic and algorithms	T_0 + 12 months
WP 4	Evaluation tests on dedicated rig	T_0 + 18 months
WP 5	Data acquisition during gearbox testing and assessment	T_0+24 months

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type (*)***	***Due Date***
D1	Report on Monitoring means identification	R	T_0 + 3 months
D2	Report on Available technology assessment	RM an R	T_0 + 5 months
D3	Report on detection logic and algorithms	R	T_0 + 12 months
D4	Report on evaluation test on rigs	R	T_0 + 18 months
D5	Report on gearbox testing results	R	T_0 + 24 months

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Requirements and CTQs defined by TM	R	T_0
M2	Sensors for rig testing availability	D	T_0 + 12 months
M3	Evaluation Test completion	RM	T_0 + 18 months
M4	Full HMS set for gearbox testing availability	D	T_0 + 18 months

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

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

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

Special Skills

- ✓ The applicant shall describe its experience/capacities in the following subjects:
- ✓ Previous experience in similar applications.
- ✓ Extensive and proven experience in mechatronics, advanced sensors technologies, for aerospace / transmission systems products, design, validation and manufacturing or procurement is mandatory.
- ✓ The Applicant needs to demonstrate to be in the position to have access to the test facilities required to perform the evaluation rig testing and meet the Topic goals; the option to use Topic Manager assets might be considered (in this case a reduced cost provision with respect to the defined Topic Budget has to be discussed).
- ✓ Experience in Supply Chain management is mandatory.
- ✓ Experience in aerospace R&T and R&D programs is a benefit.
- ✓ The activity will be managed with a Phase & Gate approach and management plan has to be provided. Topic Manager will approve gates and authorize progress to subsequent phases.
- ✓ Technical/program documentation, including planning, drawings, design reports, risk analysis, FMEA, test plan and test requirements, test results, test analysis reports must be made available to Topic Manager.

Certification:

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

IX. Electrical components

Type of action (RIA or IA)	IA		
Programme Area	FRC		
Joint Technical Programme (JTP) Ref.	WP 2.8.4		
Indicative Funding Topic Value (in k€)	500 k€		
Duration of the action (in Months)	30 months	**Indicative Start Date**[25]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-FRC-02-16	**Electrical components**
Short description (3 lines)	
Objective is to design, develop, manufacture, test and qualify up to TRL6 a High Voltage Direct Current (HVDC) technology of cables, connectors, contacts and harness insulation, protection and installation items intended to be used on a LifeRCraft Fast Rotorcraft demonstrator. Compliance with REACH regulation and optimised weight & cost are parts of the requirements.	

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

1. Background

The activity of this WP 2.8.4 Electrical components is part of the WP 2.8 Electrical System.
The objective is to develop and qualify the electrical components such as cables, connectors, … dedicated to the 270 V DC network, and to define and validate by lab tests the harness installation rules.
All components & materials that will be developed in the frame of this project:

- Must be REACH compliant.
- Must be optimised in term of weight and cost.

2. Scope of work

Tasks		
Ref. No.	***Title Description***	***Due Date***
T1	Product Description The main objective of this task is to review the Topic leader specification, to give the description of the products to be designed, manufactured, qualified and provided to the leader for bench testing, to specify the requirement for test method elaboration. Equipment interfaces need will also be analysed. → This activity will be closed by a review: Product Description Review.	T0 + 3 months
T2	Ageing study and Test method Definition The main objective of this activity is to validate the ageing key phenomenon which occur on connectors, wires and insulation means and to determine the key parameters for qualification → This activity will be closed by a review: Test Method Review.	T0 + 9months
T3	Installation rules based on architecture hypothesis The main objective of this activity is to define the harness installation means, protection and insulation means, rules, and qualification tests. Installation rules shall be conservative taking into account non compliances to standard practices e.g. chafing, excessive wire bend, compression by clamps, … Definition of sample receiving environment shall be representative to aircraft structure (edges, rivet tails, fluid and heat aggression) Two configurations will have to be taken into account, one with severe constraints and one in standard golden rules (EN3197). → This activity will be closed by a review: Installation rules and QTP1 Review.	T0 + 9 months

Tasks		
Ref. No.	***Title Description***	***Due Date***
T4	Design The main objective of this activity is to check that components preliminary design is consistent with requirement of robustness, performance, safety requirement, sizing, interface definition, drawings, prior to launch components manufacturing. Substantiation of design choice will have to be done, taking into account the T2 & T3 assumptions. The Qualification Test Plan including sampling will also be defined. → This activity will be closed by a review: First Design Review (DR1).	T0 + 15 months
T5	P1 Samples manufacturing The main objective of this activity consists of manufacturing the prototypes for tests (P1 samples are identical models in fit, form and function with the specified components defined in T4). → This activity will be closed by a Sample review and by samples delivery for customer evaluation.	T0 + 18 months
T6	P1 Samples tests This activity consists of performing the QTP on the P1 samples installed according T3 assumptions. This activity will be completed by a QTR analysis. → This activity will be closed by QTR (Qualification test report) validation and a FSQ (File Synthesis of Qualification).	T0 + 21 months
T7	Loop on Design, needed in case of T6 failure The objective of this activity is to define design correction after QTR assessment and topic leader evaluation in order to prepare P2 samples manufacturing (P2 samples are identical models in fit, form and function with the specified components at latest design that will be qualified for flight test clearance). → This activity will be closed by a Second Design Review (DR2)	T0 + 24 months
T8	P2 Samples manufacturing (if needed) The applicant will have to manufacture P2 samples according to design file validated in DR2. → This activity will be closed by a samples review and delivery for customer evaluation.	T0 + 27 months

Tasks		
Ref. No.	***Title Description***	***Due Date***
T9	P2 Samples tests (if needed) This activity consists of performing the QTP on the P2 samples to demonstrate that P2 samples are flight cleared. This activity will be completed by a new QTR analysis. → This activity will be closed by a QTR validation and a FSQ (File Synthesis of Qualification).	T0 + 30 months
T10	Harness Samples tests This activity is to make harness samples installed on a mock-up as per installation rules defined in T3 and to perform the QTP1	T0 + 30 months

General requirements:

- **Weight**: The target is to reach the lowest weight possible for the proposed components compliant with technical requirements and compatible with a serial aeronautical production and to define installation rules minimising the weight.
  For the Installation rules and QTP1 review, the partner shall provide a detail weight impact of the proposed installation rules and demonstrates that these rules will minimise the weight. Trade-off between weight reduction and cost optimisation has to be presented.
  For the Design review(s), the Partner shall provide a detailed weight analysis of the components in accordance with the requirements agreed with the topic manager. Trade-off between weight reduction and cost optimisation has to be presented.
  At QTR, an update of the weight analysis has to be presented with a substantiation of the difference with Design review version.

- **Recurring cost estimation:** The target is to obtain the optimum between the compliance with specification, minimum weight and recurring cost.
  It is applicable for Installation rules and the Component's.
  Recurring cost assessment (for a serial production) has to be presented for the Design review(s) and updated at QTR.

- **Eco-design:** The Partner shall monitor the use of hazardous substances regarding REACh regulation and select materials which are exempt of- or contain acceptable substitutes to hazardous substances, as far as possible.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D1.T1	Product Description with requirements tracking (Deliverable 1 task 1)	Document	T0 + 3 months
D1.T2	Ageing study report (Deliverable 1 task 2)	Document	T0 + 9 months
D2.T2	HVDC Ageing Test Method	Document	T0 + 9 months
D1.T3	Qualification Test Program for harnesses (QTP1)	Document	T0 + 9 months
D1.T4	Detailed design file & drawings: - Detailed design description with weight	Document	T0 + 15 months
D2.T4	Substantiation file including : - Insulation material choice	Document	T0 + 15 months
D3.T4	Safety and reliability assessment (FMEA)	Document	T0 + 15 months
D4.T4	Qualification Test Plan	Document	T0 + 15 months
D5.T4	Sampling definition	Document	T0 + 15 months
D1.T5	Sample review + samples delivery to customer	Components + Document	T0 + 18 months
D1.T6	Qualification Test Report + validation	Document	T0 + 21 months
D1.T7	Updated Design documentation after loop (if needed)	Document	T0 + 24 months
D1.T8	Updated sample review + sample delivery to customer	Document	T0 + 21 months
D1.T9	Updated Qualification Test Report if needed	Document	T0 + 30 months
D2.T9	FSQ (File Synthesis of Qualification). (Extrapolation to serial product)	Document	T0 + 30 months
D1.T10	Qualification Test Report for Harnesses (QTR1)	Document	T0 + 30 months

Milestones (when appropriate)			
Ref. No.	***Title Description***	***Type***	***Due Date***
M0	Kick off Meeting	Review	T0 + 1 month
M1.T1	Product Description Review	Review	T0 + 3 months
M1.T2	HVDC Ageing Test Method	Delivery	T0 + 9 months
M1.T3	Installation Rules Review	Review & Delivery	T0 + 9 months
M1.T4	Design Review 1 (DR1)	Review	T0 + 15 months
M1.T5	P1 Samples manufacturing	Delivery	T0 + 18 months
M1.T6	Qualification Test Report	Delivery	T0 + 21 months
M1.T7	Design Review 2 (DR2)	Review	T0 + 24 months

Milestones (when appropriate)			
Ref. No.	***Title Description***	***Type***	***Due Date***
M1.T8	P2 Samples manufacturing	Delivery	T0 + 27 months
M1.T9	Qualification Test Report FSQ (File Synthesis of Qualification). (Extrapolation to serial product)	Delivery	T0 + 30 months
M1.T10	Qualification Test Report for Harnesses (QTR1)	Delivery	T0 + 30 months
M2.T10	Electrical components available for program delivery	Delivery	T0 + 30 months

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

- ✓ Skill 1: Cable conception and manufacturing for aeronautic use
- ✓ Skill 2: Connectors and contacts conception and manufacturing for aeronautic use
- ✓ Skill 3: electrical insulation and harness protection in aerospace environment
- ✓ Skill 4: Harness installation (rules and means) in aerospace environment
- ✓ Skill 5 : Aeronautic knowledge and experience
- ✓ Skill 6 : High Voltage expertise and experience
- ✓ Skill 7 : High Voltage and ageing laboratory means
- ✓ Skill 8 : Project management between cable manufacturer, connector manufacturer and customer
- ✓ Skill 9 : Eco-design, Capacity to monitor and decrease the use of hazardous substances regarding REACH regulation.
- ✓ Skill 10: Capacity to design low weight components within an optimised recurring cost *Process*

4. Clean Sky 2 – Airframe ITD

I. Functional clear coat for natural laminar flow

Type of action (RIA or IA)	IA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	WP A-2.3		
Indicative Funding Topic Value (in k€)	680 k€		
Duration of the action (in Months)	24 months	**Indicative Start Date**[26]	Q1 2017

Identification	Title
JTI-CS2-2016-CFP03-AIR-01-15	**Functional clear coat for natural laminar flow**
Short description (3 lines)	
Development of an optically transparent functional clear coat applied over final paint scheme to protect it from erosion, contamination, icing, UV degradation and capable to dissipate electrostatic charges present at surface due to air wear. This clear coat shall be resistant enough to keep the laminar properties of the wings of business jet or HTP including leading edge as well as fairings at their optimum and prevent any increase of drag during service life.	

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

1. Background

The activity is a contribution to WP A-2.3 “Extended laminarity”.
The reduction of the aerodynamic drag of business aircraft by application of laminar technology is one of the very few remaining viable opportunities that can offer a potential of a double digit decrease of specific fuel burn. For business aircraft, the Natural Laminar Flow (NLF) technology is currently pushed forward to maturity in Clean Sky SFWA, the objective in Clean Sky 2 is to go further with large scale demonstrator in order to reach higher TRL.

The objective of the “Extended laminarity” Work-Package is to identify the concepts and to prepare the technology base that will be used in the different demonstrators embedding a laminarity objective. Extended aerodynamic performances & robustness are key points of optimal solutions, together with matching the requirements for manufacturing.

For these reasons, one fundamental need is to ensure high surface quality by the use of high performance multifunctional top coat to protect the external surface during operational life from manufacturing plant to aircraft Check C ideally (5 or 6 years in-service). Today known coatings are not able to fulfil all the requirements, especially when anti-erosion function is needed, and different surface finishes/materials are needed chord wise with difficult transition, prohibitive for natural laminar flow.

2. Scope of work

The objective of the work is to develop a new waterlike or tinted clear top coat which will be applied by conventional means on already painted surface as well as polished metallic leading edges and butt joint to prevent any degradation of drag. This clear coat or tinted coat has to meet the requirements of the general technical specification of external top coat as well as specific requirement for abrasion, erosion resistance. Provided that environmental and industrial issues are kept in mind, no restriction in term of chemistry or technology is made, however air drying or UV curing hybrid clear coat seems to be a good candidate to tailor this coatings.

An indicative high-level WBS could be as follows:

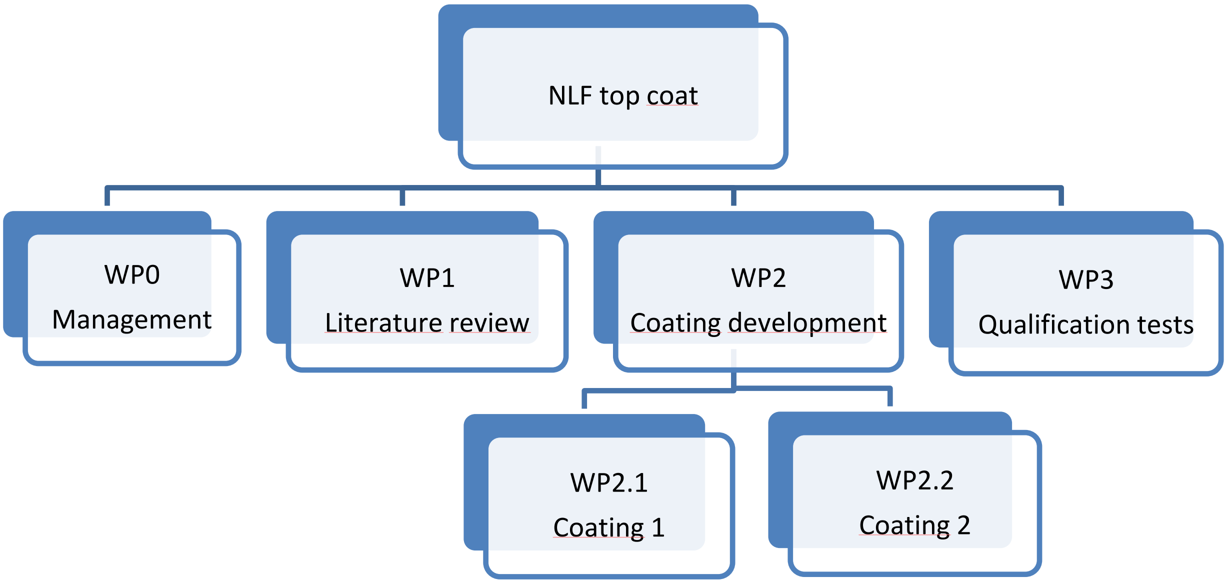


Figure 10: Work Breakdown Structure

The high level specification for the coating is the following:

Function(s)

- Protective clear coat
- Anti-erosion function
- Anti-icing/contamination function
- Anti-static function (difficult but the applicant shall take into account this requirement)

Application

- Application tool : Spray gun
- Substrates : mainly PU type finish paint(s) but could be PU type primer paint(s), Polysulfide type sealant(s), Aluminium alloy(s), Titanium(s), Nickel(s), Steel(s) and carbon or Kevlar reinforced plastics

Strength

- Sand & rain erosion
- Thermal shock
- Mechanical fatigue in singularity areas (fasteners, panels junction …)
- Resistance to fluids (including water, fuel, lubricants/greases, hydraulic fluids, de-icing, cleaning solvent ...) or other contamination

Adhesion

- Substrates listed in Application
- Hydrophobic (to avoid ice accretion, contamination from dirt, insects ...)

Aesthetic

- Optically transparent glossy varnish (uncoloured)
- UV & Fluids resistance

Maintenance/Repairability

- The varnish shall be easily repaired, especially small local areas

A non-exhaustive list of quantitative requirements is presented in tables below:

The following table collects a set of substrates to be used during the validation process.

Ref	Substrate	Thickness (mm)	Surface treatment
A1/**A2**	2024 T3	1,6/**0,8**	CAA + basic primer + final paint scheme
D	2024 A5	1,6	Pickled

Tables of required properties call up these references.

Properties	Substrate	Unit	Test methods	Criteria
Gloss 20°, 60°	A2	GU	ISO 2813	20°: >80 60°: > 92°
Hardness	A1	g	ISO 1518	>1500
Cross cut adhesion	A1, D	G	ISO 2409	G<1
Flexibility at room temperature =8mm	A2	°	ISO 1519	180°, No cracks, no peeling
Flexibility at –55°C =40 mm	A2	°	ISO 1519	180°, No cracks, no peeling
Resistance After 7 days air drying Resistance after forced cured 8H 60°C	To be defined with TM	M	To be agreed	30 - 50 M 30 - 50 M

Properties after ageing (Primer + Surfacer + Finish + Clear coat)

Properties	Substrate	Scratch	Unity	Check according to	Criteria
Resistance to cold crack temperature cycle AITM 2.0016	A2	No	G °	Exposure Cycle 3 ISO 4628/2 ISO 2409 ISO 1519 (= 8 mm) (F= 25 mm at -55°C)	No cracking G<1 180° 180°
Resistance to deicing fluid (taxiway and structure) ISO 11075	A1 Tbd w TM	Yes	g G GU E M	Immersion 168H at 23°C per ISO 2812/1 ISO 4628 ISO 1518 ISO 2409 ISO 2813 (60°) ISO 7724 Image clarity Resistance	No cracks >1200g G<1 > 90 GU < 0,6 30-50 M
Fastness to light QUV (2000H 4H UVB 50°C/4H Condensed) Natural weathering (Florida: Not mandatory providing that no colour change occur after IR/visible exposure) DSC	A1 Free film	No	GU DE G ° ° MΩ °C	After exposure EN 13523-10 ISO 4628 ISO 2813(20, 60°) ISO 7724 ISO 2409 ISO 1519 (= 8 mm at 23°C) ISO 1519 (= 25 mm at -55°C Resistivity Tg	>80, >92 GU E< 0,6 G<1 No cracks at 180° No crack at 180° 30-50 M < 20°C
Rain erosion resistance	Dedicated panel	No		V : 220 m/s angles: 15°-30° Drop: 0.3	Ra< 0.8µm

After all accelerated ageing, profilometry and wave scan measurement shall be carried out to detect any modification of the surface roughness.

A short description of the expected activities in order to fulfil the topic is provided below.

a) Management tasks – WP0

This work package will provide the management of the project in order to ensure that all the obligation of the Applicant are fully respected, from a contractual, financial and technical point of view. The Applicant shall organise the work and report to Topic Manager (TM) all along the project.

b) Literature review – WP1

The objective of this work package is to carry out a literature review regarding available coatings, technologies, processes that could help to fulfil all the technical requirements. The outputs of this work package will be the literature review document itself and the conclusion will put forward and describe at least 2 different coatings to be developed in WP2.

c) Coating development – WP2

Scope: This work package is the core activity of the proposed topic, i.e. the development of the coating itself. The technical requirements being challenging, the proposal and development of at least two different routes shall be pursued, in order to avoid dead ends.
For both coatings (or more if considered appropriate), the first step shall be the formulation of the coating at laboratory scale. The second step shall be the elementary characterization of the developed formulation (physical-chemical, adhesion ...). If necessary, several iterations might be necessary to end with an optimized coating. The last step shall be the production of a small scale batch in order to carry out advanced characterization and industrial evaluation.

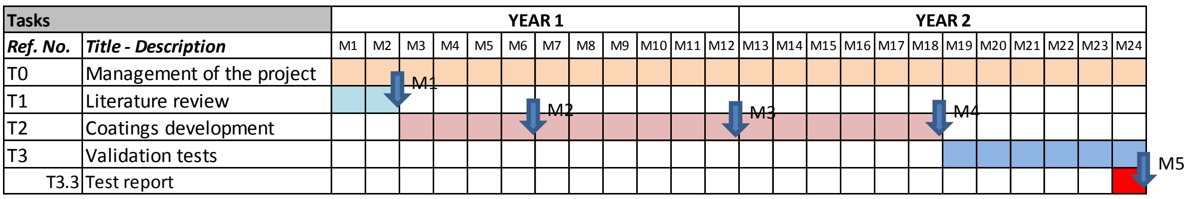
Coating 1 – WP2.1: The first coating to be developed shall be applied using traditional varnish or paint aerospace equipments.

Coating 2 – WP2.2: The second coating developed shall follow a more innovative solution, however taking into account industrial constraints.

d) Validation tests – WP3

The purpose of this work package is to carry out tests in accordance with the coating technical requirements on one or both developed coatings. At the end of tests, the main objective is to be able to mitigate the risk and propose the coating for large scale ground or flight NLF demonstration.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T0	Management of the project	
T1	Literature review	M1
T1.1	Bibliographical study	
T1.2	Theoretical study of 2 formulations and processing routes	
T2	Coatings development	
T2.1	Coating 1	
T2.1.1	Coating formulation	M2 & M3
T2.1.2	Coating characterization	M2 & M3
T2.1.3	Small batch production run for advanced evaluation	M4
T2.2	Coating 2	
T2.2.1	Coating formulation	M2 & M3
T2.2.2	Coating characterization	M2 & M3
T2.2.3	Small batch production run for advanced evaluation	M4
T3	Validation tests	M5
T3.1	Tests on 1st coating (depending on development conclusions)	
T3.2	Tests on 2nd coating (depending on development conclusions)	
T3.3	Test report	



3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1.1	Literature review report	Document	M1
D1.2	Development work plan	Document	M1
D2.1	Coatings formulation status	Document	M2
D2.2	Coating characterization status	Document	M3
D2.3	Intermediate development report	Document	M3
D2.4	Coatings development final report	document	M4
D2.5	Small batches coating production & control	Material + document	M4
D3.1	Test report	document	M5

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M0	Kick Off Meeting	Meeting	T0
M1	Literature review	Meeting	T0+2 months
M2	1st intermediate development review	Meeting	T0+6 months
M3	2nd intermediate development review	Meeting	T0+12 months
M4	End of coatings development	Meeting	T0+18 months
M5	Final report - Test results	Meeting	T0+24 months

Applicant Mission and IPR's

The mission of the applicant will be to develop coatings taking into account the TM recommendations and provided technical specification. The TM will provide the adequate informations to enable the Applicant to perform the requested activities. Further innovations and improvements and recommendations from specific studies and analysis proposed by the Applicant will be welcomed.

All the information and data to be exchanged between the TM and the Beneficiary of the topic 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

The applicant shall have a large experience in coating development and industrialization for aeronautical applications (formulation, laboratory testing, industrial manufacturing and customer support)

The applicant shall have capability to consider future industrial constraint.

II. Design Guide Lines and Simulation Methods for Additive Manufactured Titanium Components

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€)	800 k€		
Duration of the action (in Months)	36 months	**Indicative Start Date**[27]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-AIR-01-16	**Design Guide Lines and Simulation Methods for Additive Manufactured Titanium Components**
Short description (3 lines)	
Metal additive manufacturing (AM) allows complex and unique product geometries which can reduce both product cost and weight. Guidelines and best practice methods for AM titanium need to be established as well as finite element topology optimization (TO) able to handle AM characteristics.	

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

1. Background

This topic is part of Airframe High Performance and Energy Efficiency (Activity Line A). The topic is one of the key research activities which will ultimately result in the demonstration of an innovative structural design with strategic complex shapes and material for an efficient fuselage. This topic is part of Work Package A-3.3: Innovative shapes & structures.

Moveable, load bearing and flight critical aircraft structures such as cargo doors can be fairly complex products and a typical cargo door can consist of hundreds of individual parts, a number of relatively large (>1kg) metallic parts which can be machined, forged or in some cases cast. Additive manufacturing (AM) has shown great promise within the aerospace industry for the manufacture of such parts, offering potential benefits in terms of weight, design/functionality, lead time and cost/ manufacturability.

Within Work Package A-3.3 newly developed tools will be used to evaluate current/typical cargo door parts in terms of their manufacturability, cost and design/weight. The parts identified as candidates for AM will be those showing the greatest potential for cost and weight reduction.

Additive manufacturing (AM) is a relatively new production method that allows the manufacturer to automatically create components directly from a computer model. The method is especially useful for companies with low production rate and large variation of components and beneficial for components in materials that are expensive and/or difficult to process. AM can be used to produce industrial parts that are both lighter in weight, cheaper to produce, and with complex geometries that are difficult or impossible to produce with conventional methods. The mechanical properties of AM-components can differ substantially from the properties of the same component produced by conventional techniques. This is due to the inherent complexity of the AM-methods and the large quantity of process parameters including layer thickness, energy density, scan strategy, scan speed and preheating temperature.

The primary concern for commercial aerospace structures is the fatigue performance, a property that is highly sensitive to issues associated with AM, such as porosity, residual stresses, build orientation and surface condition. Sometimes post-processing, such as hot isostatic pressure, heat treatment, machining or polishing of AM parts are needed to further increase the fatigue performance and make it comparable to conventionally wrought material. To be able to introduce AM in critical or highly loaded metallic aircraft parts, a deeper understanding of how the AM process and built geometry influences the material performance is needed. New ways of handling topology optimization (TO) and failure simulations are also needed to fully utilize the freedom of design available for AM components.

This document describes an indicative structure, the main activities to be performed, a general time schedule, the expected deliverables and the general requirements that shall be considered for the selection of an appropriate partner.

2. Scope of work

The activity, object of this Call, is aimed to address the following areas:

- Material characterization. Determine the effect of geometry and surface roughness and optimize fatigue performance by cost effective surface post processing.
- Validation of designs solutions and creation of design rules. To verify material models and computational tools used in AM development by experimental testing on AM manufactured parts, both in lab environment and industrial settings. Based on the result from both modelling and experimental activities generic design rules will be obtained and integrated in computer-aided engineering (CAE) environments.
- Efficient and optimal design. How can the product and the additive manufacturing process be optimized to obtain the best properties for each particular application? Based on outcome of the point above this will be addressed through efficient computer-aided design (CAD) modelling and topology optimization as well through optimization of material properties by post surface processing.
- The manufactured parts. What parts of a product and its production system are best suited for additive manufacturing? That is, how to determine which parts in a complex assembly to manufacture using additive manufacturing, and in what stages of the product lifecycle (e.g. prototyping, development or service)?

These research areas have been divided into four work packages (WP).

Work Packages		
Ref. No.	***Title – Description***	***Due Date***
WP 1	Material properties and post processing	T0+36
WP 2	Topology optimization and structural strength	T0+36
WP 3	Design for additive manufacturing	T0+36
WP 4	Demonstrator, concepts for weight reduction	T0+36

WP1 - Material Properties and Post Processing

During powder bed AM processes, a product is formed by selectively melting successive layers of powder by the interaction of a laser or electron beam. Even though conventional powder metallic alloys are used, the mechanical properties of AM-components can differ substantially from the properties of the same component produced by conventional techniques. To ensure safety in air travel it is very important for the aerospace industry that the AM-components meet the stringent requirements of the industry and that the products can achieve the robust performance levels established by traditional manufacturing methods. Typically, the AM method gives a very fine-grained weld-like microstructure and sometimes the solidification process can lead to a columnar grain structure. As a result, the properties of the AM produced material are often anisotropic and depend on the building orientation. Furthermore, since different process parameters are used for contour material and bulk material, the material properties will also depend on the part geometry especially for thin walled structures. Other issues associated with AM that need to be considered include porosity and residual stresses.

Power based additive manufactured titanium alloy Ti-6Al-4V is of major interest for the aircraft industry and shall be the primary focus in this project. The geometry dependent material behaviour of thin walled structures as well as the influence of the surface roughness needs to be investigated. Cost effective surface post processing, e.g. vibratory grinding or electro-polishing, shall be evaluated and characterized to further increase the fatigue performance of AM parts.

AM test material shall be subcontracted by the applicant or produced in-house by the applicant.

WP 1 - Material properties and Post Processing		
Ref. No.	***Title – Description***	***Due Date***
WP 1.1	Material characterization	T0+24
WP 1.2	Increased fatigue properties through cost effective surface post processing	T0+24
WP 1.3	Geometry dependent material behaviour	T0+30

WP 2 - Topology Optimization and Structural Strength

To fully utilize the freedom of design available for AM components computer based methods for structural optimization should be used. Among such methods, topology optimization (TO) is the most powerful. One reason why TO still is limited to being a conceptual tool is that optimized structures, which may be very complex with many internal holes and small details, can be difficult or even impossible to manufacture. Additive manufacturing (AM) now changes the design limitations, in principle making it possible to realize any design suggested by TO software. However, in order to fully leverage the potentially powerful combination of TO and AM it is necessary to take into account certain limitations/properties of the technology in the design optimization process since material properties and surface roughness are very much dependent on the AM part geometry and built direction. By including the AM built orientation as a variable factor in the design optimization process, one should be able to not only determine what the optimal design should look, but also the best way to manufacture it.

The project shall also address the importance of accounting for uncertainties. Two sources of uncertainty in the AM build process are the material properties and residual stresses accumulated in the build process. To meet the stringent safety requirements of the aerospace industry, uncertainty should be handled within the framework of robust optimization using worst case scenarios.

This WP includes extension of classical TO models and methods to include some essential characteristics of AM components, i.e.

1. Elastic anisotropic material behavior, experimentally determined in WP1.
2. Inclusion of the AM build process orientation as an additional design variable in order to obtain the best orientation, and in that way exploiting the anisotropic properties to ones favor.
3. Extension of stress constrained methods to include plastic properties (yield surfaces), experimentally determined in WP1.
4. Extension to include graded materials and material with different surface and bulk material, which is essential to properly describe thin structural parts. Data needed for this is determined in WP1.
5. Extension of TO worst-case strategies to include uncertainty in material properties as well as residual stresses and applicable fatigue life damage parameters.
6. Study redundancy requirements for structural safety (Fail-Safe) and its impact on construction design and rules.

TO software requirements: The specific TO methods and tools, essential for full use of AM technology in this project, are very advanced and presently not accessible in commercial software. Moreover, the required methods are at the cutting each of research in TO and requires access to a software system in which they can be implemented tested and validated during the development and within the project duration period in a coherent and effective way.

The applicant thus needs to have access to program code and experience of software for general finite element analysis, conceptual design, topology optimization and numerical modelling of imperfections and defects (cracks) with the ability and access to add new functionality to existing code. The software shall be able to communicate with general state-of-the-art CAD systems for mechanical design such as CATIA in order to facilitate effective interaction and collaboration with the other work packages in the project.

WP 2- Topology Optimization and Structural Strength		
Ref. No.	***Title – Description***	***Due Date***
WP 2.1	Establish communication between Catia software and FEA/TO software.	T0+12
WP 2.2	Topology optimization (TO) methods for AM geometries	T0+30
WP 2.3	Structural Strength simulation method for complex AM geometries	T0+30
WP 2.4	Best practice guidelines for metal AM TO and stress simulation	T0+32

WP 3 - Design for Additive Manufacturing

AM will naturally influence the way products are produced in the future as both the technologies and materials are being improved. However, there is also a big change to be expected in the way products are being designed to best leverage on the properties of AM, which is a central part of this project. Furthermore, the product development process is also likely to change as traditional manufacturing to a large extend has had a huge impact on the product development process itself.

Traditional manufacturing is by itself time consuming, and it also requires other activities like production development, tooling design and production planning; activities that would be obsolete, or need to be performed very differently when components are being produced using AM technology. Furthermore, the reduction of manufacturing lead-time will ensure that production is no longer the bottleneck in the development process, and hence put an even greater focus on the design stage of the product realization process.

There is a huge potential in connecting all the CAE-software used in the product development process in a homogenous computational framework, to enable holistic design optimization. However, there are also other aspects that need to be considered after TO. The topology optimized structures need to be transferred into generic CAD systems and assembled to complete systems to facilitate holistic product optimization considering other properties such as, system dynamics, thermal properties, manufacturing and assembly, system interactions, cost and many more. The CAD model thus constitutes the link between these domains, and parametric CAD models together with advanced multi-disciplinary optimization techniques are essential to obtain truly optimal systems.
In this project CAE methods for metal AM shall be developed including connection of TO and CAE tools with flexible parametric CAD models.

Today, design rules and principles are based on constraints and requirements originating from traditional manufacturing and also the CAE-software used is developed based on traditional manufacturing. In this project best practice design guidelines for metal AM shall be produced. The best practice guidelines shall include a step by step approach for AM design with good and bad examples of design solutions. The best practice guidelines shall also include guidelines with criteria on when a product is considered suitable for AM and guidelines on how tolerances for complex AM designs shall be defined on drawings and in models.

WP 3- Design for Additive Manufacturing		
Ref. No.	***Title – Description***	***Due Date***
WP 3.1	Demands and tolerances for complex AM design and modeling	T0+12
WP 3.2	CAE methods for metal AM, including connection of TO and CAE tools with flexible parametric CAD models.	T0+24
WP 3.3	Best practice guidelines for metal AM design (DfAM)	T0+32

WP 4 - Demonstrator, Concepts for Weight Reduction

The finite element analysis (FEA) and the TO-optimization process make it possible to significantly reduce the weight of an AM part. Three (3) design concepts for one component selected by the Topic manager shall be designed. Examples of possible demonstrator components are presented in Figure 1. The focus shall be on reduced weight through innovative design and topology optimization but also aspects like cost and surface roughness shall be considered. Ends user requirements for the demonstrator part shall be defined at the beginning of this project in collaboration with the Topic manager. Mechanical behaviour of the innovated design concept shall be verified trough component-like specimen testing.

WP 4 – Demonstrator, Concepts for Weight Reduction		
Ref. No.	***Title – Description***	***Due Date***
WP 4.1	End user requirements	T0+6
WP 4.2	Design concepts and topology optimization	T0+30
WP 4.3	Stress modelling of design concepts	T0+30
WP 4.4	Component-like specimen testing	T0+34

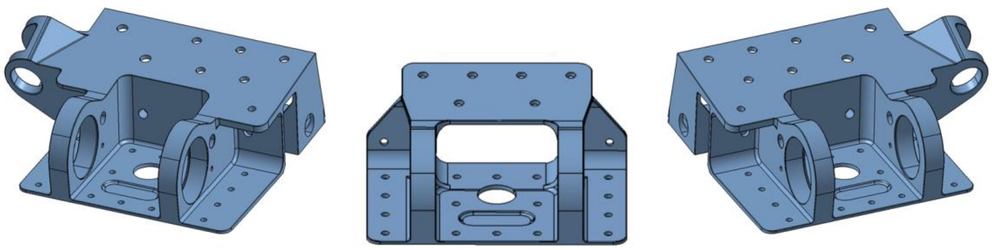


Figure 1 Example of possible candidates for additive manufacture: A Shear fitting and Latch fitting on a typical Cargo-Door. The above parts are typically forged/machined.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Established communication between Catia software and FEA/TO software.	Report	T0+12
D2	Material characterization of surface and anisotropy properties	Report	T0+24
D3	Computer implementation of a TO method that takes into account and optimizes the properties of material anisotropy due to AM build orientation	Report	T0+24
D4	Improved fatigue properties through cost effective surface post processing	Report	T0+24
D5	Computer implementation that, in addition to D3, includes uncertainties in material properties and residual stresses	Report	T0+30
D6	Three (3) design concepts for the demonstrator component with weight reduction focus	Report	T0+30
D7	Best practice guidelines for metal AM design	Report	T0+32
D8	Best practice guidelines for metal AM, TO and stress simulation	Report	T0+32
D9	General metal AM guidelines including D7 and D8	Report	T0+36

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Defined end user requirements	Meeting	T0+6
M2	Progress report meeting	Meeting	T0+6
M3	Demonstrator draft concepts acceptance by topic manager	Meeting	T0+24
M4	Progress report meeting	Meeting	T0+24
M5	Innovative concept design verified by component-like testing	Testing	T0+34

D= deliverable, M = milestone

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

Special skills:

- Proven experience in collaborating with aeronautical companies and in associated research and technology programs.
- Experience in structural, shape and large scale topology optimization.
- Experience in so-called robust deterministic topology optimization.
- Experience in material investigations of metal AM material.
- Experience in deformation and damage mechanisms of metallic materials and structural strength modelling.
- Experience in parametric modelling in general state-of-the-art CAD systems for mechanical design e.g. CATIA, and connection to advanced CAE environments and optimization frameworks.

Capabilities:

- Mechanical testing facilities including tensile testing, fracture toughness testing, fatigue testing, fatigue crack propagation testing and hardness testing.
- Residual stress measurement facilities.
- Heat treatment facilities (heat treatment up to at least 900°C).
- Microstructural investigation facilities including light microscopy and SEM+EBSD.
- Sample preparation facilities.
- Surface polishing facilities (e.g. electro-polishing).
- CATIA CAD software, V5 R24 or later.
- Abaqus Finite Element Analysis software, V6.12 or later.
- Access to a finite element TO software for industrial applications
- Capability of adding new fine-tuned TO-methods at any levels of the software above

5. Abbreviations

AM	Additive manufacturing
CAD	Computer-aided design
CAE	Computer-aided engineering
EBSD	Electron backscatter diffraction
FEA	Finite element analysis
SEM	Scanning electron microscope
TO	Topology optimization
WP	Work Package

III. Orbital Drilling of small (<10mm diameter) holes, standardly spaced with aluminium material in the stack

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€)	500 k€		
Duration of the action (in Months)	36 months	**Indicative Start Date**[28]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-AIR-01-17	**Orbital Drilling of small (<10mm diameter) holes, standardly spaced with aluminium material in the stack**
Short description (3 lines)	
There are two lines of research proposed in this call, both related to the development of orbital drilling. The first is to introduce residual stress when drilling in aluminium, this is seen as the main reason orbital drilling is not more widely used in the aerospace industry. The second is to enable drilling of smaller holes positioned closer together (a limitation with existing machines/methods).	

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

1. Background

This topic is part of Airframe High Performance and Energy Efficiency (Activity Line A) and more specifically is defined in Work Package (WP) A-3.3: Innovative shapes & structures.

Aircraft structures such as cargo doors can be fairly complex products and a typical cargo door can consist of hundreds of individual parts which need to be assembled together. Orbital Drilling is well established within the aerospace industry and has provided excellent results for larger holes with stacks containing typically a combination of carbon fibre, titanium and steel.

Orbital drilling can be seen as a combination of milling and drilling, a cutting tool that is smaller than the planned hole diameter revolves around its own axis with pressure against the surface while orbiting to create the hole diameter. Benefits of orbital drilling include burr free holes, reduction in number of drill bits (diameters) required in production, larger repeatability and no need for cooling liquid. The risk for poor quality holes is minimal and it is a clean drilling method with efficient removal of drill chips and dust.

Automated drilling solutions will be crucial to increase the competitiveness of the European aerospace industry; reducing manufacturing costs whilst reducing the likelihood of rework or scrap parts due to drilling operation errors. In addition, current production lines which were built on technologies available many years ago do not always use solutions which would be chosen with today’s knowledge and technology. Automated orbital drilling has the potential to significantly reduce production time and cost for both new and current production lines.

There are at present only a handful of products on the market for orbital drilling, and none of these machines offer a solution for aluminium, nor for tightly spaced holes. Recent research has revealed that there is a struggle to achieve the same benefits from orbital drilling in aluminium, as in titanium and carbon fibre. Compared to conventional drilling a lower but more controlled force is applied against the processed surface providing lower residual stress when compared with traditional drill and ream procedures, this is an issue for aluminium where the residual stress provides better fatigue resistance. It is of great interest to overcome these issues as aluminium is an important material used in the aerospace industry. A series of proposals have been made in recent research projects, and one of the objectives with this call is to develop and evaluate these proposals.

Within Work Package A-3.3 the development of a new state-of art orbital drilling unit for drilling small holes in aluminium, in combination with a suitable method to drill smaller holes in close proximity to each other, is proposed. The drilling unit shall be light enough to be handled both by an operator and a light weight industry robot (paving the way for a fully automated solution). It shall also ensure that there are no burrs between stacks until the installation of fasteners can be conducted, thus paving the way for one-way assembly. Furthermore the topic is also to investigate how orbital drilling in aluminium alloys should be conducted, in order to attain residual stress in the material surrounding the hole.

This document describes the indicative work structure, a general time schedule, the expected deliverables and the general requirements that shall be considered for the selection of an appropriate partner.

Figure 1. Typical assembly where orbital drilling could offer substantial benefits over traditional drilling methods

2. Scope of work

The activities planned for this call will result in the demonstration of residual stresses in aluminium when drilling small (<10mm diameter) holes with standard spacing, suitable material stacks containing aluminium shall be used. This will be performed through investigation, concept study and the design and production of a prototype for a suitable Orbital drilling unit.

The call is split up into the following work packages (WP):

Work Packages		
Ref. No.	***Title – Description***	***Due Date***
WP 1	Investigation of orbital drilling in aluminium alloys	T0+18
WP 2	Orbital drilling unit capable of drilling smaller holes (<10mm) standardly spaced, in various airframe material, including aluminium and hybrid joints	T0+36
WP 3	Verify and demonstrate the functionality of the prototype	T0+36

WP1 – Investigation of orbital drilling in aluminium alloys

Orbital drilling has shown great benefits in material such as composites, titanium and steel. The objective of this WP is to introduce residual stress in stacks containing aluminium.

An investigation of orbital drilling in aluminium alloys used in aero structures has to be performed in order to study the factors altering the properties of the material. Finite Element Analysis (FEA) and simulations shall be used as first attempts to investigate the sequence of events occurring during the drilling operation in aluminium alloys. Following the computer aided analyses; physical samples shall be made and tested. Mechanical tests shall be conducted to assess the impact of the fastener on the fatigue life of applications containing Aluminium. The physical tests are to be analysed and compared to the FEA and simulations. The fasteners types and stack material(s) & thicknesses will be defined by the topic manager.

WP 1 shall analyse the material properties of orbital drilling in aluminium alloys used in aero structures. It shall find root causes for the issues surrounding the low induced residual stress and suggest solutions on how to control and design the orbital drilling equipment in order to increase this residual stress. In addition, functional testing of the equipment shall be defined in this WP providing input and preparing for such a process in WP 3. This WP is intended to be conducted in parallel to WP 2 and 3.

Pre-study reports, physical sample reports, and a verification and test plan, are important deliverables of this WP and are required prior to the start of the other WPs. Partial results are set to be delivered halfway through the project timeline, but additional work may be required throughout the project.

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T1.1	End user requirements definition	T0+6
T1.2	Pre-studies of material properties during Orbital Drilling (FEA & Simulations)	T0+12
T1.3	Physical samples manufactured and tested, including fastener effects on fatigue life	T0+12
T1.4	Definition of test plan and functionality verification	T0+16

WP 2 – Orbital drilling unit capable of drilling smaller holes (<10mm) standardly spaced, in various airframe material, including aluminium and hybrid joints

The WP will focus on the development of an Orbital drilling unit capable of drilling of small (<10mm diameter) holes, standardly spaced. The holes shall be drilled in various airframe materials such as aluminium, composite and titanium, including hybrid joints based on these materials. The machine shall be capable of both normal and countersunk holes and shall fulfil the requirements for one way assembly (where the drilled stack does not have to be separated for deburr/cleaning). The drilling unit and associated drill bit(s) shall be developed in accordance to the qualification process for cutting tools and machines as defined by the topic manager. All holes drilled shall also meet the requirements specified by the topic manager. Typical requirements include the allowable hole diameter, process capability value (Cpk), surface finish, perpendicularity, ovality etc.
Several variables as defined in the qualification process to be provided by the topic manager (axial force, rotation/feed speed, distance/gap between stack materials etc.) shall be monitored, recorded and controlled during trials. These variables shall be discussed and agreed with the topic manager in

order to find the optimum combination.
Due to the relatively large size of the machine head on current orbital drilling machines, it is difficult to drill small holes which are typically positioned closer to each other (the drill jig which must house the machine head is one of the main reasons for this). It is expected that the partner proposes a suitable solution, either involving a novel redesign of the machine head/drill jig or through incorporating an automated approach which will not require a drill jig.
The developed drilling unit shall be light weight and must be either manual handled or by a lightweight industry robot. As with today's orbital drilling machines, clean equipment that does not involve coolant is required, any process waste shall be removed effectively so that the production environment remains as clean as possible. It is essential to define end user requirements for the developed unit, both for the final demonstration in WP3 as well as for use in production. This shall be discussed and agreed with the topic manager. Cooperation with potential end users of the product in the aero structure industry is recommended to bring further feasibility to the concept.

This WP is intended to be conducted in parallel to WP 1, and the results will be used in WP 3 in form of a prototype for demonstration, testing and verification.

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T2.1	Define a suitable orbital drilling solution	T0+18
T2.2	Develop and present a number of concepts	T0+20
T2.3	Manufacture a Prototype	T0+30

WP 3 –Verify and demonstrate the functionality of the prototype

The focus of WP 3 is to verify if the requirements previously defined for orbital drilling in aluminium can be achieved with the prototype. Testing should follow where possible the qualification process which the topic manager will define. The topic manager will actively participate during this phase providing expertise from an end-user perspective.

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T3.1	Tests and validation of process	T0+36
T3.2	Tests and validation of equipment	T0+36

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Pre-studies report	Report	T0+12
D2	Physical samples report	Report	T0+24
D3	Verification and test plan	Report	T0+16
D4	Concept design/review meeting	Report	T0+24
D5	Validation test report Prototype	Report	T0+36

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	End-user requirements definition	Report	T0+6
M2	Data input for prototype	Report	T0+18
M3	Prototype made	Test	T0+30
M4	Test and verification of functionality of prototype	Report	T0+36
M5	Demonstration of principles for orbital drilling equipment on simple geometry	Test	T0+36

D= deliverable, M = milestone

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

Special skills:

- Proven experience in collaborating with aeronautical companies Research and Technology programs
- Proven experience in Orbital Drilling in the aeronautical field.
- Experience in technological research and development for innovative products and processes.
- Experience of drilling technology in different types of materials.

Capabilities:

- Sample preparation facilities
- CAD software
- FEA software
- Machining spindle simulation software
- Machining process simulation software

- Cutting force measurement
- Additional software if relevant need to be able to communicate with general state-of-the-art CAD systems for mechanical design
- Strategic and operative sourcing
- Assembly and testing of high precision mechanic/mechatronic systems
- Drilling and hole measurement

Access to:

- Mechanical testing facilities (tensile testing, fracture toughness testing, fatigue testing, fatigue crack propagation testing, hardness testing)
- Microstructural investigation facilities (light microscopy, SEM)
- Additional software for general finite element analysis, conceptual design, topology optimization and numerical modelling of imperfections and defects (cracks) with access to add new functionality to existing available software if needed to perform the work.

IV. Research and development of a compact drilling and fastening unit suitable for a range of standard 2 piece fasteners

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€)	500 k€		
Duration of the action (in Months)	36 months	**Indicative Start Date**[29]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-AIR-01-18	**Research and development of a compact drilling and fastening unit suitable for a range of standard 2 piece fasteners**
Short description (3 lines)	
One way assembly (OWA) gives lower time to market and lower production/product cost and thereby increases the competitiveness within the aerospace industry. There is currently a number of drilling and fastening solutions on the market which support OWA, however there is no such system which is compact enough to be either handled manually or by a single light weight industrial robot. A suitable end effector which can work in conjunction with humans and robots is desired.	

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

1. Background

This topic is part of Airframe High Performance and Energy Efficiency (Activity Line A). The topic is one of the key research activities which will ultimately result in the demonstration of an innovative structural design with strategic complex shapes and material for an efficient fuselage. This topic is part of Work Package A-3.3: Innovative shapes & structures.

Aircraft structures such as cargo doors can be fairly complex products and a typical cargo door can consist of hundreds of individual parts. This means that a large number of parts will have to be assembled during manufacturing. Automated solutions will be crucial to increase the competitiveness of the European aerospace industry.

The operations involved in the assembly of two or more parts such as drilling, fastening and sealing, are typically carried out in separate operations traditionally done by hand with the help of Automatic Drilling Unit (ADU) or NC-equipment. Recent advances in automation, miniaturisation and man-machine integration make this area of aircraft assembly a key area for research activities. In addition to the cost benefits health and safety risks can be reduced by not having to handle hazardous compounds, such as sealant.

Current aircraft programs are limited in their use of automated drilling and fastening solutions, there is however a trend towards increasing automation and this is of increasing importance as competition within the aircraft industry increases. The applications that are typically chosen for automation are the larger assemblies with a large number of holes and fasteners to be drilled/inserted in areas which allow relatively unhindered access.

One Way Assembly (OWA) is a method used to eliminate the 'non-value added' activity associated with aircraft structure assembly (dismantling, clean & de-burr). OWA must ensure that no swarf can enter the area between the materials being drilled, and that the burr height is low/nonexistent, this ensures that knockdown factors in fatigue analyses are avoided.

The objective of this call is to develop a new compact drilling and fastening unit for OWA. The unit/end effector should be innovatively designed to be handled by operator(s) or by lightweight industrial robots in collaboration with humans. The drilling and fastening unit shall be suitable for a range of standard 2 piece aerospace fasteners. The equipment should ensure that the requirements for OWA are met and that wet assembly (sealant requirements) of the fasteners can be conducted. It is expected (although not compulsory) that the proposed solution is of the cooperative type between robot and human.

This document describes the work packages (WP), a general time schedule, the expected deliverables and the general requirements that should be met by any appropriate partner.

Figure 1. Typical assembly where one way assembly and automated fastening would be preferred

2. Scope of work

The call is split up into the following work packages (WP):

Work Packages		
Ref. No.	***Title – Description***	***Due Date***
WP 1	Robot/Operator interaction in an OWA robot cell.	T0+36
WP 2	Development of a compact automated end-effector, combining drilling and fastening operations performed by light weight industrial robot(s)/operator(s)	T0+36
WP 3	Test plan for OWA and verification of method for hole quality and fastener installation according to requirements for commercial aircraft structures	T0+36
WP 4	Demonstration of concept	T0+36

WP 1 - Robot/Operator interaction in an OWA robot cell

Trends seen currently in the area of robot development include an increased focus on combining emerging sensor technology with more specialised robots in different sizes and payload capability.
There are several robot suppliers that have robot arms with 7-axis today and these improve reachability towards more complex geometries and also inside enclosed spaces. Furthermore, different sensors and technologies, i.e. force sensors, camera technologies and laser tracking, are combined with robots in different ways. The next step is to combine the Human and Robot in a Collaborative way sharing the same working volume. Here, regulations are currently being reviewed and several initiatives to evaluate how to work collaboratively are being evaluated in a number of research projects in Europe. In this work package combining OWA with Human-Robot-Collaboration (HRC) requires an overall strategy for the collaboration between human and robot and which is

responsible for each task. Careful consideration should be made to any changes or expected changes in the human machine directive which results from the ongoing activities in this field.

The proposed solution has to be compact and light so that it can be handled in the normal range of manoeuvrability and workload for a human hand and/or by a light weight industrial robot. How the tasks and resources are divided between human/robotic operations has to be optimised during the development stage.

In WP 1 the assembly stages and layout for a typical airframe structure shall be assessed and optimised for the new semi-automated/automated assembly method proposed. Typical assembly stages will be provided by the topic leader, these will need to be analysed in more detail in order to understand which work moments are to be conducted. An optimised production layout including required safety barriers, work fixtures and the various positions in time of the machine(s), end effector(s), ADU(s) and personnel shall be defined. Furthermore, a risk assessment for the production layout shall be developed. This WP is intended to be conducted in parallel to WPs 2, 3 and 4.

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T1.1	Develop a step by step process description	T0+36
T1.2	Propose a suitable production layout	T0+36
T1.3	Propose a suitable interaction method between operator(s) and robot(s)	T0+36
T1.4	Risk assessment of proposed production layout	T0+36

WP 2 – Compact automated end-effector, combining drilling and fastening operations performed by light weight industrial robot(s)/operator(s)

WP 2 will focus on the development of a compact automated end-effector for OWA. The solution shall fulfil requirements for clamping, positioning and orientation of the end-effector in addition to the drilling, countersink, sealing of fastener and fastening of final fastener (these requirements will be provided by the topic leader). Several inputs (force control, gap measuring/control, fastener type, fastener feed, tightening to specific torque, sealant, etc.) can be considered and shall be discussed with the topic leader during the developmental stage. Finding an appropriate solution to induce a sufficient clamping force is of major importance as it determines whether contaminants will enter the stack being drilled. A solution is sought which maintains pressure/compression in the stack throughout any tool changes required between drilling and fastening. Separation of the drilled stack between these operations is not allowed. Application of sealant on nut and/or fastener needs to be incorporated into the solutions presented. The application of sealant should also meet the requirements to be presented by the topic leader.

The material stack and thicknesses to be drilled are to be defined in conjunction with the topic leader, however Carbon Fibre – Aluminium stacks are intended to be the major focus. The drilling and fastening unit(s) shall be suitable for a range of standard fasteners; these are to be defined by the topic leader

A major challenge with this work will be to achieve a state-of-art compact and light weight OWA unit(s) diversified from the heavy existing alternatives, comprising all the necessary equipment for successful hole operations and final fastening. The solution has to be smart in the way the operations are carried out from the unit or units, equipping the right tools to the operator/robot will be of great importance. It will not be possible to incorporate all of the required functionality in a single unit as the weight will exceed that which can be handled by a human/light weight industry robot.

The way power is distributed from the power source to the equipment shall be studied as this could have a significant impact on the weight.

Another key area of research and development in this topic is how the requirements for hole quality and fastener installation are met and verified. Depending on the solution (how much is automated and how much is manual) the end effector shall be capable of verifying the hole quality before a fastener is inserted. The fastener installation then needs to be verified so that it also meets the specific requirements such as applied torque and sealant coverage. A suitable solution to this verification process shall be presented. An automated solution is preferred.

This WP is intended to be conducted in parallel to WPs 1, 3 and 4.

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T2.1	Conduct benchmarking of existing equipment and similar solutions	T0+9
T2.2	Define a suitable solution(s) that meets the requirements	T0+18
T2.3	Establish a number of concepts/prototypes and demonstrate functionality	T0+30

WP 3 – Test plan of OWA method and fastener installation according to requirements for commercial aircraft structures

WP 3 shall focus on establishing a test plan for the requirements associated with the qualification of the OWA process for parts in production. The specific requirements will be provided by the topic leader.The second part of this work package shall focus on design for manufacture. Best practices regarding design for OWA shall be documented; this should be provided in the form of design guidelines. It shall cover different material combinations and a range of geometries and thicknesses to be discussed with the topic manager. The document shall provide the design engineer with a good understanding of when OWA is possible and not possible (taking into account the research developments made as part of this topic).

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T3.1	Test plan of the specific requirements associated with the qualification	T0+30
T3.2	OWA design guidelines	T0+24

WP 4 - Demonstration of concept

This work package shall begin with the definition of end user requirements. This shall be conducted together with the topic leader to ensure that all requirements are met.

The focus in this WP will then be the demonstration of the developed technologies and proof of concept. Important parameters such as time and cost reduction shall be evaluated and presented. After evaluation of all of the concepts one of them (in agreement with the topic manager) shall be manufactured for testing and evaluation, the mechanical behaviour and performance of the solution shall be demonstrated using a number of suitable specimens to be defined by the topic manager.

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T4.1	End user requirements definition	T0+6
T4.2	Testing of concept with specimen testing	T0+30
T4.3	Verify if the requirements can be met	T0+36

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Concept review meeting	Report	T0+18
D2	OWA design of parts for demonstration	Report	T0+24
D3	Test plan for proof of concept	Report	T0+30
D4	Definition of Robot/Operator interaction in an OWA robot cell.	Report	T0+30
D5	Develop a step by step process description	Report	T0+36
D6	Verify if the requirements can be met	Report	T0+36

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	End user requirements definition	Report	T0+6
M2	Requirements for collaboration schemes between robot and operator in the OWA cell	Report	T0+9
M3	Description of potential collaboration schemes between robot and operator in the OWA cell	Report	T0+15
M4	Prototype made	Test	T0+30
M5	Demonstration of principles for OWA equipment on simple geometry/OWA designed metal parts	Test	T0+36

D= deliverable, M = milestone

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

Special skills:

- Experience in drilling and fastening procedures in commercial aircraft structures
- Experience in drilling and fastening equipment for commercial aircraft structures
- Experience in technological research and development for innovative processes
- Experience of Human/robot interaction
- Experience with adaptive robot control strategies (force or sensor input driven) is also beneficial.
- Experience with designing optimized working loops for controlling the robot and identifying optimal control paths is preferred.

Capabilities:

- Testing facilities
- Microstructural investigation facilities (light microscopy, SEM)
- Sample preparation facilities
- Catia CAD software (version to be specified by the topic manage), likely V5R24 or later.

A documented involvement of the applicant in aerospace R&D programs together with the ability to bring new and innovative ideas to laboratory demonstrator is highly valuable.

V. Hybrid Aircraft Seating Requirement Specification and Design - HAIRD

Type of action (RIA or IA)	IA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	WP A-3.4		
Indicative Funding Topic Value (in k€)	250 k€		
Duration of the action (in Months)	12 months	**Indicative Start Date**[30]	Q1 2017

Identification	Title
JTI-CS2-2016-CFP03-AIR-01-19	**Hybrid Aircraft Seating Requirement Specification and Design - HAIRD**
Short description (3 lines)	
The objective of the topic is the design and layout of a new seating structure including seating cushions. The seating structure will consists out of hybrid material having less weight and high degree of function integration. In addition, the design needs to improve the recyclability of the structure which means a fast dismantling process after use.	

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

1. Background

In large passenger aircraft several hundred aircraft seats ensure comfort and safety of the passengers. These seats are replaced over the life time of an aircraft several times. Aircrafts seats are thus a major component in all passenger aircraft, and fast disassembling and dismantling are needed to recycle all parts of the seating structures.

Aircraft industry will face massive challenges in the next years. Despite the fact that air traffic is responsible for less than 2% of the global CO_2-emissions, industry is forced to reduce fuel consumption and emissions. High production rates for future aircrafts require effective production methods beside the high degree of integration of different components and functions.

Hybrid materials and structures offer the potential for achieving both mentioned key challenges, but recycling of the materials after use has not been yet satisfactory solved. To reduce the environmental footprint of the aircraft, it is also necessary to develop a dismantling concept for hybrid materials & structures and in addition to develop efficient manufacturing processes with high degree of functions integration.

The specification of future seatings with regard to technical and comfort aspects will be the base for the design of the innovative hybrid seating structure. From the design, materials and process will be derived to manufacture the hybrid seating structure. Materials and functional integration will be selected with the substantive criteria of weight reduction and effective processes. Special attention will be given to the dismantling possibility of the different materials to simplify the recycling process.

The final objective of the call is the set-up of a demonstrator of a hybrid seating structure with:

- max. 10 kg weight for seating in economy class
- functional integration in light-weight design e.g. compact design, multi-functionality (electric conductive, optical transparent, actuating elements), energy and material efficient during use phase, cost efficient production by reducing complexity of components and manufacturing time
- easy dismantling of the seat
- recyclability of at least 90% of the weight of the seating structure
- metal components of the structure should be replaced by carbon-fibre based parts

2. Scope of work

The proposed activities can be organised in two main tasks.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 1	Analysis, specification and general concept of future seating design under technological and ecological aspects The specifications for the hybrid seating structures will be defined. This will guide development of the individual technologies and their integration into the hybrid seating structure.	T0+06
Task 2	Design and layout of the hybrid aircraft seating under technological and ecological aspects. Taking into account the information gathered in the previous task, the whole hybrid seating structure will be designed and validated by a numerical simulation.	T0+12
Task 2.1	Design of the seating structure and cushion	T0+09
Task 2.2	Numerical calculation of the composite structure	T0+12

Task 1: Analysis, specification and general concept of future seating design

Concerning specification, the objective of the work is to define the needs and requirements of future hybrid aircraft seating in regard of easy dismantling and recycling. In addition the needs and requirements for comfort as well as the integration of functions in future seating will be determined. The specification will be the basis for the general concept of future seating.

Task 2: Design and layout of the hybrid aircraft seating

Starting from the general concept, the seating structure will be designed with the support of numerical tools. The design will take the loads acting on the structure, dismantling and recycling and fire-smoke toxic aspects into account. The specified functions and its integration need to be considered.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	First report on the principle design of the hybrid seating structure	Report	T0+6
D2	Report on specification and general concept of future seating design	Report	T0+12

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Specification (Report) and first concept of seating cushion (CAD file)	Maturity Gate	T0+06
M2	Complete CAD Model	Maturity Gate	T0+12

	1	2	3	4	5	6	7	8	9	10	11	12
Task 1												
Task 2												
Task 2.1												
Task 2.2						M1/D1						M2/D2

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

- The applicant shall have a proven strong background and expertise in design and structural analysis of composite parts.

VI. Flexible Test Rig of Aircraft Control Surfaces powered by EMAs

Type of action (RIA or IA)	IA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	WP B-1.3, B-2.2, B-3.2		
Indicative Funding Topic Value (in k€)	510 k€		
Duration of the action (in Months)	36 months	**Indicative Start Date**[31]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-AIR-02-17	**Flexible Test Rig of Aircraft Control Surfaces powered by EMAs**
Short description (3 lines)	
The control surfaces and actuation systems of the Regional FTB2 Demonstrator new wing devices are designed within Airframe ITD. This topic describes the design, manufacturing and power on of a flexible test rig for systems on-ground tests of actuation on flaps, ailerons, spoilers and winglets.	

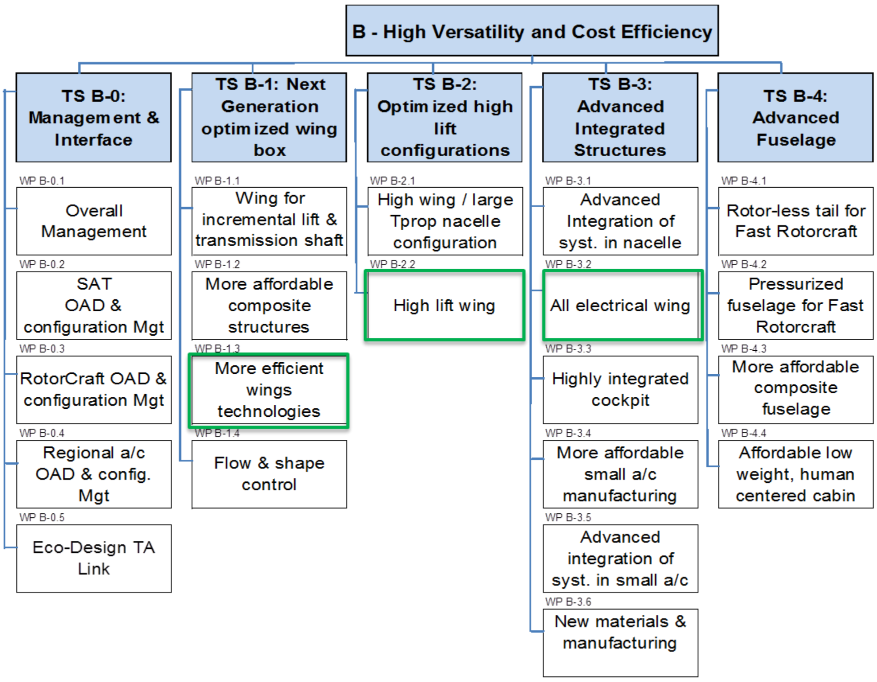
[31] The start date corresponds to actual start date with all legal documents in place.

1. Background

This topic deals with the state of the art in technologies developed for rigs test control surfaces actuation systems of regional aircrafts. The facilities and equipment proposed will be used to test on ground actuation systems of ailerons, flaps, spoiler and winglet proposed by the Topic Manager in the context of Clean Sky 2 Regional FTB2 demonstrator.

The framework of this topic is AIRFRAME ITD *Work Packages AIR B-3.2 All Electrical Wing, AIR B-1.3 More Efficient Wing Technologies and AIR B-2.2 High Lift Wing* where specific wing innovative control surfaces are designed and tested. These control surfaces are actuated by electro-mechanical actuators (EMAs) defined in every work-package (aileron and spoiler in AIR B-3.2, winglet tab in AIR B-1.3 and flap actuation system and tab in AIR B-2.2) and developed in SYSTEMS ITD.

A flexible test rig is required to integrate the actuation and the counter-effects of the airframe aerodynamic and reaction loads under aircraft operating conditions.



The activities under this Call for Proposal (CfP) will support the development of all electrical wing actuated and sourced innovative Regional Turboprop Aircraft (A/C) concept, FTB2, of the topic manager targeting the Horizon 2020 objectives as described in the JTP document of Clean Sky 2 (CS2).

The FTB2 demonstrator is based on the topic manager turbo prop transport aircraft with high wing configuration thrusted by two turboprops. So far several efforts have been made in order to enhance the aircraft performances with new wing control surfaces (aileron, flap, spoiler and winglet). This effort in order to achieve a better A/C is aligned with the CS2 objectives of getting more efficient and green transport. depicts the FTB2 Demonstrator and the innovative control surfaces actuated by EMAs.

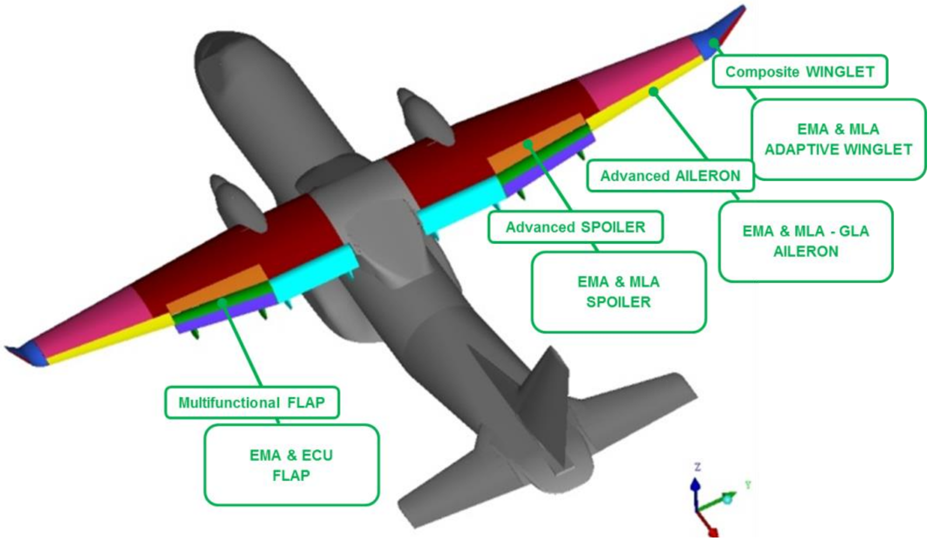


Figure 11: Regional FTB2 A/C innovative control surfaces

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

The objective of this topic is to develop the necessary test benches related to ailerons, spoilers, flap tabs & winglets tabs surfaces, in order to reproduce complete A/C conditions that will be present in the FTB2 prototype A/C, regarding the actuation of these surfaces. The project covers the design, manufacturing and power on of the different test benches related to the above referred A/C surfaces, all of them commanded by electromechanical actuators (EMA) connected to A/C electrical system at FTB2 prototype A/C.

The test means shall be fully representative of A/C environment at which surface dedicated EMAs will be tested, in terms of real A/C loads that EMAs shall withstand, surfaces inertia representative of real A/C surfaces, and stiffness of mechanical interfaces at which EMAs are connected representative of those present in the real A/C.

The test means are intended to be used to:

- Validate the EMAs and its corresponding actuation systems under real working conditions (A/C surface real loads), applying the real inertia in each case, taking into account the representability in terms of stiffness, and introducing and measuring the corresponding antagonism loads.
- Validate the electrical consumption of each EMA actuation system, in stationary and dynamic conditions, representative of A/C in terms of the applied load and the required command to A/C surface in each test case.

- Validate the influence of EMAs actuation system in A/C electrical network representative rig.
- In the case of ailerons, at which a combined solution of HA and EMA is selected, to validate the influence of EMAs actuation system in A/C hydraulic network representative rig, regarding the influence on the adjacent HA that is used for actuation of the aileron surface.

The proposed generic architecture for a test bench at which an EMA actuation system is considered as the equipment under test, is represented in the following figure, on which the elements inside the dotted line are the elements that shall be considered in the scope of the following CfP.

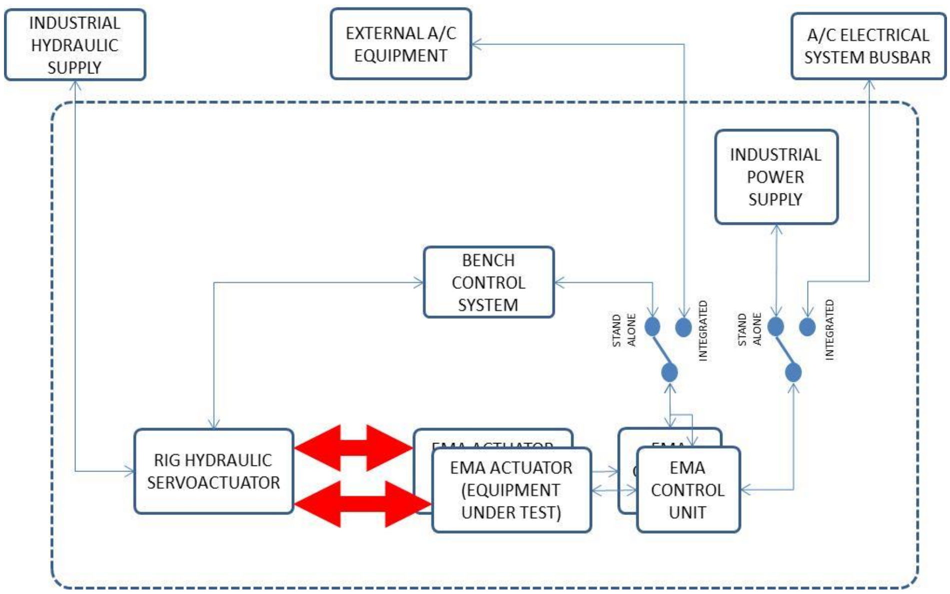


Figure 12. Generic test bench architecture for EMA actuator

The main elements related to the test bench are:

1. EMA actuator + EMA control unit: this is the equipment under test. The bench shall consider the corresponding mechanical and electrical (at power and signal level) interfaces to allow representative operation of the equipment at the test bench.
2. Rig Hydraulic Servo-actuator: a hydraulic servo-actuator is preferred as the best option that allows reproducing A/C real operation load profiles. Design criteria shall be accomplish with load introduction requirements at surface level as far as dynamic response necessary to provide the dynamic required profiles. It is hydraulically connected to an existing industrial hydraulic supply.
3. Mechanical link: it is represented in red. It shall have a representative lever radius and angular range, or representative linear stroke, depending of the EMA mechanical integration within the mechanical actuation of the surface. A load cell shall be considered at every EMA mechanical link in order to measure the load applied for each EMA.
4. Bench control system: it shall implement the following functions:
   - To control the entire bench in stand-alone mode, generating & recording the

corresponding commands to the Rig Hydraulic Servo-actuator and to the EMA control unit.

- To receive, monitor and record the corresponding parameters received from EMA control unit during EMA operation both in stand/alone and integrated mode.
- In integrated mode it shall have the capability of implement A/C model simulations or receive the corresponding load parameters to be applied to rig actuator from A/C model simulations running outside test bench perimeter.
- In integrated mode it shall have the capability to monitor the corresponding commands issued by bench external A/C equipment to the EMA control unit.
- To acquire, monitor and record the corresponding load parameters as far as electrical parameters such as DC voltage and DC current.
- To implement warnings and alarms which their corresponding protective functions in order to guarantee the mechanical & electrical integrity of the whole test bench installation during operation.

5. Industrial DC power supply: two industrial power supplies for 270Vdc and for 28Vdc shall be considered and shared for all the test benches under the scope of this CfP. This power supplies shall provide electrical power to all the EMAs and its associated Control Units.
6. Switching capability: required to the test bench to work under stand alone or integrated mode:
    - In stand-alone mode the actuation system is validated in terms of working under real conditions (A/C surface real loads), applying the real inertia in each case, taking into account the representability in terms of stiffness, and introducing and measuring the corresponding antagonism loads. The switching capability will also allow measuring the electrical consumption of each EMA to adjust the required A/C electrical loads and commands to each surface.
    - In integrated mode, the integrated rig will allow to evaluate the complete effects of EMAs-based actuation system on the A/C electrical network. For this purpose, the test bench shall have the capability to be connected to a representative and existing A/C electrical generation and distribution rig, which is fully representative in terms of generation, distribution & power wire lengths.
    - In the integrated mode, the aileron rig will require a combined solution to work:
        - In a first step with two HAs per surface connected to an hydraulic generation and distribution rig (provided by the leader and out of the scope of the topic)
        - In a second step with one HA and one EMA per surface connected to hydraulic and electrical generation and distributions rigs (provided by the leader and out of the scope of the topic)
7. Electrical parameters to be measured: DC voltage and current consumption at the input of every EMA, with enough sample rate to perform power quality tests in stand/alone mode, according to applicable standard.
8. In the case of Aileron test bench, it shall be measured the pressure applied to A/C Aileron HA actuator.

An innovative modular approach of the tests benched is proposed in order to develop a flexible and affordable complete rig assembly. The surfaces rigs may be grouped in independent test benches with compatible links in between.

Surface	Equipment under test	Bench mechanical architecture
Aileron LH	1 (EMA + CU) 1 (HA + CU)	BENCH ACTUATOR ↔ HA BENCH ACTUATOR ↔ EMA
Aileron RH	1 (EMA + CU) 1 (HA + CU)	BENCH ACTUATOR ↔ HA BENCH ACTUATOR ↔ EMA
Spoiler LH	2 (EMA + CU)	BENCH ACTUATOR ↔ EMA BENCH ACTUATOR ↔ EMA
Spoiler RH	2 (EMA + CU)	BENCH ACTUATOR ↔ EMA BENCH ACTUATOR ↔ EMA
Flap-Tab LH	1 (EMA + CU)	BENCH ACTUATOR ↔ EMA
Flap-Tab RH	1 (EMA + CU)	BENCH ACTUATOR ↔ EMA
Winglet-Tab LH	1 (EMA + CU)	BENCH ACTUATOR ↔ EMA
Winglet-Tab RH	1 (EMA + CU)	BENCH ACTUATOR ↔ EMA

Table 2: EMA Test Benches Mechanical configurations

The technology challenges of the topic are summarized in the following table.

Table 3: Technology challenges in the Flexible Test Rig for different A/C surfaces powered by EMAS

COMPONENT	TECHNOLOGY CHALLENGES	TECHNOLOGY DEMONSTRATORS
Aileron EMA/HA based actuation control system	To investigate the load sharing between EMA/HA actuators against an real A/C loads, in static and dynamic conditions, in order to select the best algorithm applied to EMA control unit and HA control unit respectively in terms of transients loads and effects on aileron surface control minimization.	EMA Aileron test Bench (WP 1)

COMPONENT	TECHNOLOGY CHALLENGES	TECHNOLOGY DEMONSTRATORS
	To investigate the electrical consumption and 270VDC electrical network influence during all the operation cases of aileron operation and/or electrical network reconfigurations in order to select the appropriate approach to minimize the impact and transients to 270VDC electrical network. To investigate the hydraulic consumption and hydraulic network influence during all the operation cases of aileron operation.	
Spoiler EMA based actuator control system	To investigate the EMA behaviour against a real A/C loads, in static and dynamic conditions, in order to select the best algorithm applied to EMA control unit, in terms of transitory loads and effects on aileron surface control minimization. To investigate the electrical consumption and 270VDC electrical network influence during all the operation cases of spoiler operation and/or electrical network reconfigurations in order to select the appropriate approach to minimize the impact and transients to 270VDC electrical network.	EMA Spoiler test Bench (WP 2)
Flap Tab EMA based actuator control system	To investigate the EMA behaviour against a real A/C loads, in static and dynamic conditions, in order to select the best algorithm applied to EMA control unit, in terms of transitory loads and effects on aileron surface control minimization. To investigate the electrical consumption and 28VDC electrical network influence during all the operation cases of flap operation and/or electrical network reconfigurations.	EMA Flap Tab test Bench (WP 3)
Winglet Tab EMA based actuator control system	To investigate the EMA behaviour against a real A/C loads, in static and dynamic conditions, in order to select the best algorithm applied to EMA control unit, in terms of transitory loads and effects on aileron surface control minimization. To investigate the electrical consumption and 28VDC electrical network influence during all the operation cases of winglet operation and/or electrical network reconfigurations.	EMA Winglet Tab test Bench (WP 4)

Work Packages and Tasks description

The Topic is organised in four technical Work Packages devoted to specific control surface actuation:

- WP1: EMA Aileron Test Bench
- WP2: EMA Spoiler Test Bench
- WP3: EMA Flap Tab Test Bench
- WP4: EMA Winglet Tab Test Bench

Every WP shall be under the Applicant accountability; however the Topic Manager will contribute to the conceptual design, as well as the system specification in order to define all the interface requirements between the test bench and the connected equipment (A/C and/or industrial).

Table 4: Tasks definition and description of activities

Tasks					
Ref. No.	***Title – Description***	***Due Date WP 1***	***Due Date WP 2***	***Due Date WP 3***	***Due Date WP 4***
Task X.1	KOM: kick off meeting	T0	T0 + 5	T0 + 11	T0 + 11
Task X.2	Analysis of the mechanical, electrical and control/acquisition requirements	T0 + 1	T0 + 6	T0 + 12	T0 + 12
Task X.3	Mechanical and Bench Structural calculations	T0 + 2	T0 + 7	T0 + 13	T0 + 13
Task X.4	Control system definition	T0 + 2	T0 + 7	T0 + 13	T0 + 13
Task X.5	Trade-off for selection of the industrial elements to be included in the bench	T0 + 3	T0 + 7	T0 + 14	T0 + 14
Task X.6	Mechanical CATIA design for bench manufacturing	T0 + 3	T0 + 8	T0 + 14	T0 + 14
Task X.7	SW specification for Control System	T0 + 3	T0 + 8	T0 + 14	T0 + 14
Task X.8	PDR: preliminary design review	T0 + 3	T0 + 8	T0 + 14	T0 + 14
Task X.9	CDR: critical design review	T0 + 4	T0 + 8	T0 + 15	T0 + 15
Task X.10	Manufacturing	T0 + 5	T0 + 10	T0 + 16	T0 + 16
Task X.11	SW specific development for Control System	T0 + 6	T0 + 11	T0 + 17	T0 + 17
Task X.12	Acceptance Test Procedure Definition	T0 + 7	T0 + 12	T0 + 18	T0 + 18
Task X.13	CISS: customer inspection at supplier site	T0 + 8	T0 + 13	T0 + 19	T0 + 19
Task X.14	CIPS: customer inspection at purchaser site	T0 + 8	T0 + 13	T0 + 19	T0 + 19
Task X.15	POWER ON: power on of the test bench	T0 + 9	T0 + 14	T0 + 20	T0 + 20
Task 16	Support of Rigs Integration (common to WP 1, 2, 3 and 4)	T0 + 36			

Note: X refers to WP 1, 2, 3 and 4 respectively

Requirements and Specifications

Each test bench shall be fully representative of A/C EMA/HA mechanical interfaces, in terms of: stiffness, lever distance, inertia, lug & bolt shape at actuator side and specific pieces relating to bolts & lugs installation.

Once designed the lug of each test bench, it shall be validated by the Topic Manager in order to check the stiffness required value to be fully representative.

Less costing materials may be considered if the mechanical properties are similar to A/C materials, previously agreed with Topic Manager.

Each test bench shall consider the installation of the Control Unit related to each A/C EMA/HA, in the same bench or in an external rack. In all of the cases the necessary A/C connectors shall be provided in order to connect A/C equipment as in the real A/C.

Wiring between Control Unit and the corresponding EMA shall be fully representative of the A/C wiring in terms of cable type used & length.

Regarding to the mechanical link, a load cell of traction – compression shall be implemented in each case with the proper conditioner in order to measure the applied loads to each A/C actuator. The dynamic response of the set load cell + conditioner shall be enough to monitor the dynamic behaviour of the equipment under test.

Each test bench shall provide the capability of stand-alone configuration and integrated configuration, in order to fulfil with the use terms of the bench. For this purpose, contactors & relays shall be used in order to guarantee the switching capability in terms of power and signal lines respectively.

At signal lines, patch panels shall be provided, with manual and switching capability, in order to simulate the corresponding failures at every EMA subsystem and validate the response in terms of loads withstanding and also electrical and hydraulic network influences.

Control system shall implement functions listed in chapter 2 of this document, developed under a RT system environment.

Control system shall be developed by using National Instruments HW & SW. The SW code shall comply with the corresponding specifications and also shall be provided unblocked in order to allow further modifications if required in the future.

In stand-alone mode, a power supplies with enough capacity shall be provided – this element may be shared by all the EMAs benches considered in this CfP - in order to supply 270VDC EMAs and 28VDC to the different EMAs and their control systems under tests.

Each set of EMA + Control Unit connected to electrical network (stand-alone or integrated) shall be protected upwards by the use of the corresponding RCCB or CB that will be defined. For this purpose, each test bench shall incorporate a distribution box, connected to electrical network, at which these elements are considered. It shall also be considered the installation -in series with RCCBs or CB- of the corresponding contactor in order to switch on/ switch off remotely the system EMA + Control Unit.

Electrical parameters shall be acquired by isolated channels: voltage and current. Current shall be measured by a non-intrusive method. Sample rate and dynamic response of current sensors and used conditioners shall be enough to capture transients. It shall be defined by the Leader.

Analog parameters such as pressure and force shall be acquired by isolated channels. Sample rate and dynamic response of current sensors and used conditioners shall be enough to capture transients.
Discrete parameters shall be acquired by a non-intrusive acquisition device at a rate of 1Ksample/sec.
Communication Bus parameters (tbc bus type) shall be acquired also at a suitable rate to capture all the information variations provided by A/C equipment into the communication bus.
Regarding to integration with other benches, an interface panel with connectors type D3899 series or similar shall be provided, and the corresponding power and signal harnesses to interconnect with external A/C equipment and/or rigs.
A test bench manual shall be provided –as the deliverable of the POWER ON task- containing the following documentation:

- User manual
- Electrical drawings (files to be provided in Autocad 12 or similar)
- Mechanical design (files to be provided in CATIA V5, release 21 or lower)
- SW functionality
- SW open code (files to be provided in Labview V14)
- List of industrial parts and contacts.
- Results of ATP passed to the bench at Customer site.

Effort and costs

An estimation of the effort between the activities is suggested below. Furthermore, details about budget distribution are welcome.

Table 5 Effort required for each main component/activity within the project

COMPONENT/ACTIVITY	Effort estimated
EMA Aileron Test Bench	40%
EMA Spoiler Test Bench	30%
EMA Flap Tab Test Bench	15%
EMA Winglet Tab Test Bench	15%

Inputs and Outputs

Topic Manager will provide the following information to the Beneficiary:

- Equipment under test functional specifications
- Equipment under test mechanical and electrical definition (ICDs)
- ICDs of the A/C equipment considered in integration mode
- Aircraft CAD model files (CATIA, STEP or IGES) related to the specific equipment under tests

* Support in the activities defined in along the Topic to ensure full-compatibility of the rigs.

The outputs from the Beneficiary of this call are the following ones:

* Technical Documentation required.
* Delivery of test rigs of aileron, spoiler, flap tab and winglet tab with capacities described to work in stand-alone mode and integrated mode with the rest of A/C system.

3. Major deliverables/ Milestones and schedule (estimate)

The deliverables and milestones are in accordance with the general work plan of the Regional Aircraft FTB2 demonstrator shown in Figure 3 at the topic publication date. After finalization of individual rigs, an activity of support to the leader in the rigs integration is identified until complete maturation of the whole on-ground test bench.

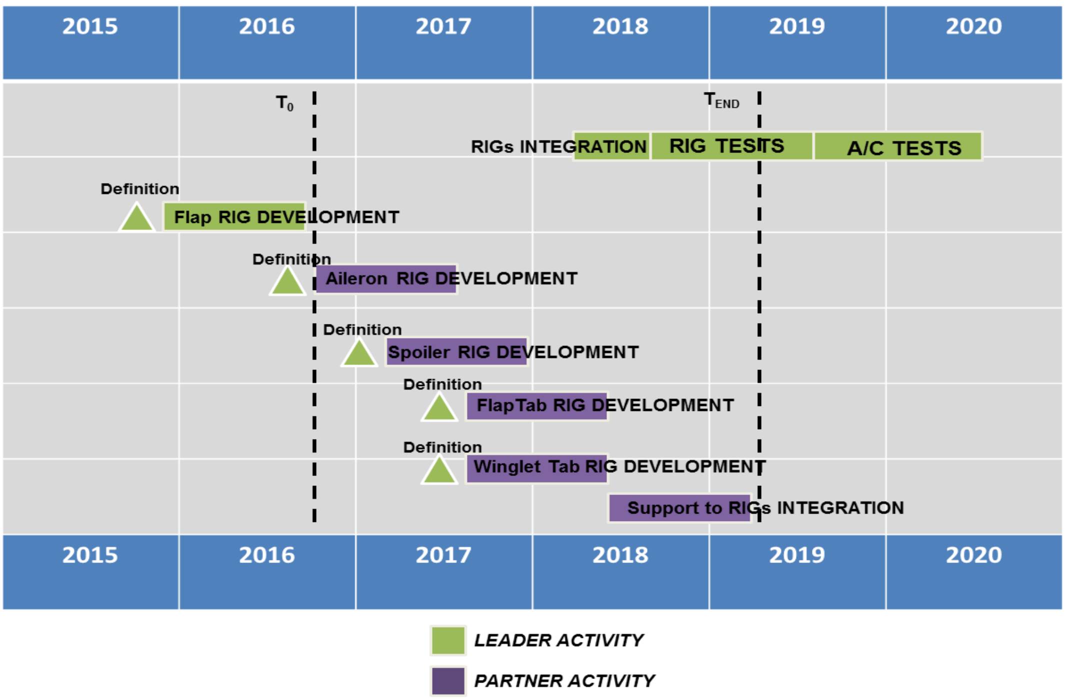


Figure 13. Planning for the Regional Aircraft FTB2 vs. Flexible test rig for different aircraft surfaces powered by EMAs. Activities of Leader and of Partner. (Best estimation at publication date)

Table 5: List of FTB2 Demonstrator Principal Milestones.

Ref. No.	***Title - Description***	***Due Date WP1***	***Due Date WP2***	***Due Date WP3***	***Due Date WP4***
MX.0	**Test Bench KOM**	T0	T0+5	T0+11	T0+11
MX.1	Test Bench PDR	T0+3	T0+8	T0+14	T0+14
MX.2	Test Bench CDR	T0+4	T0+9	T0+15	T0+15

Ref. No.	*Title - Description*	*Due Date WP1*	*Due Date WP2*	*Due Date WP3*	*Due Date WP4*
MX.3	Test Bench CISS	T0+7	T0+12	T0+18	T0+18
MX.4	**Test Bench POWER ON**	T0+9	T0+14	T0+20	T0+20

Note: X refers to WP 1, 2, 3 and 4 respectively

Table 6 List of main deliverables

Deliverables						
Ref. No.	*Title - Description*	*Type*	*Due Date WP1*	*Due Date WP2*	*Due Date WP3*	*Due Date WP4*
DX.1	Analysis of the mechanical, electrical and control/acquisition requirements	Document	T0 + 1	T0 + 6	T0 + 12	T0 + 12
DX.2	Trade-off for selection of the industrial elements to be included in the bench	Document	T0 + 3	T0 + 7	T0 + 14	T0 + 14
DX.3	Acceptance Test Procedure Definition	Document	T0 + 7	T0 + 12	T0 + 18	T0 + 18
DX.4	CIPS: partner inspection at Topic Manager site	Document	T0 + 8	T0 + 13	T0 + 19	T0 + 19
DX.5	POWER ON: power on of the test bench	Document	T0 + 9	T0 + 14	T0 + 20	T0 + 20
D.6	Support of Rigs Integration (common to WP 1, 2, 3 and 4)	Document	T0 + 36			

Note: X refers to WP 1, 2, 3 and 4 respectively

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

- Solid knowledge and capabilities for designing and manufacturing mechanical and electronic test benches.
- Solid knowledge of CATIA model design
- Solid knowledge of control and acquisition systems based on National Instruments HW&SW
- Proven experience in collaborating with reference aeronautical and aerospace companies in R&T programs
- Participation in international R&T projects cooperating with industrial partners
- Knowledge and experience in resistance of materials calculations and material selection properties for designing the test benches
- Engineering software and licenses for Computer Aided Design (CAD), and appropriate high performance computing facilities
- Engineering software and licenses for Labview, and appropriate high performance computing

facilities

- Experience in integration of multidisciplinary teams in concurring engineering within reference aeronautical companies
- Capability of specifying, performing and managing, in collaboration with the Topic Manager, the following
  - Analysis of the mechanical, electrical and control/acquisition requirements
  - Control system definition
  - Trade-off for selection of the industrial elements to be included in the bench
  - Mechanical CATIA design for bench manufacturing
  - SW specification for Control System
  - Acceptance Test Procedure Definition
- Structural and Systems Design and Simulation capacities: structural analysis (i.e. NASTRAN), and design tools (CATIA v5)
- Deep knowledge and experience in the following standards: DO-178C, DO-160G, ARINC 791, ARINC 429, MIL 1553, ARINC 600
- Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004)

5. Abbreviations

A/C	Aircraft
CAD	Computer Aided Design
CB	Circuit Breaker
CDR	Critical Design Review
CfP	Call for Proposal
CISS	Customer Inspection at Suppliers Site
CS2	Clean Sky 2
CU	Control Unit
EMA	Electro Mechanical Actuator
HA	Hydraulic Actuator
ICD	Interface Control Document
JTP	Joint Technical Proposal
KON	Kick off meeting
LH	Left Hand
PDR	Preliminary Design Review
RCCB	Remote Controlled Circuit Breaker
RH	Right Hand
R&T	Research and Technology
SW	Software
TBC	To be confirmed
WP	Work Package

VII. Prototype Tooling for subcomponents manufacturing for wing winglet

Type of action (RIA or IA)	IA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	B-1.3.1		
Indicative Funding Topic Value (in k€)	600 k€		
Duration of the action (in Months)	18 months	**Indicative Start Date**[32]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-AIR-02-18	**Prototype Tooling for subcomponents manufacturing for wing winglet**
Short description (3 lines)	
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 needed to manufacture both LH & RH wing winglets to be mounted on Regional Aircraft FTB2 demonstrator.	

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

1. Background

This Call for Proposal is allocated into the frame of Clean Sky 2 where several demonstrators will be developed by the industry. The tasks within this project involve components from the **Regional Aircraft IADP**, although the technology development related to these activities is part of Airframe ITD WP B-1.3.

The Regional Aircraft FTB2 is a prototype aircraft based on the EADS – CASA C295 model. This aircraft is Civil FAR 25 certified by FAA and EASA Airworthiness Regulations with large in-service experience as regional aircraft which is a very suitable platform to test in flight Clean Sky 2 mature technologies.

Figure 14. Regional Aircraft FTB2: EADS-CASA C295.

The structural components required within the framework of this Call for Partner belong to the wing of the Regional Aircraft FTB2, in particular to the winglet of the wing.

The component will be composed of skins, ribs, spars, leading edge and trailing edge, tab and tip. These components will be manufactured with maximum level of integration and reducing assembling work.

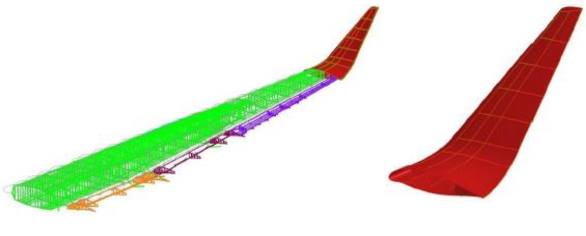


Figure 15. Assembled wing – left, Winglet: component – right.

The proposed materials to manufacture the parts shall be preferably composite suitable for Autoclave and Out of Autoclave processes (OoA). The selected technology to manufacture the different winglet parts shall be LRI, RTM, one shot process, high integrated structures in order to reduce the assembly task, weight saving based on the avoid of rivets and mechanical fasteners, etc.…

The Partner that will be selected for this Call will be responsible to develop, design, manufacture and deliver to the Topic Manager (TM) the tooling set for all single parts needed to manufacture both LH & RH winglets in accordance with the materials, manufacturing processes and technical specifications selected or developed by the Topic Manager.

The development of this tooling should be innovative in order to implement the best performances in the following fields:

- Low Cost/ Natural Materials,
- Eco-design,
- Energy savings,
- Manufacturing processes simplification-Production time savings, always ensuring that each one of the single parts manufactured with the prototype tooling fit with the Aeronautical quality standards.

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 the Regional Aircraft FTB2 demonstrator.
The approximate maximum dimensions will be around 2x1,5 meters
The winglet comprises the following structural sub elements.

- Leading edge
- Trailing edge/tab
- Tip
- Torsion box

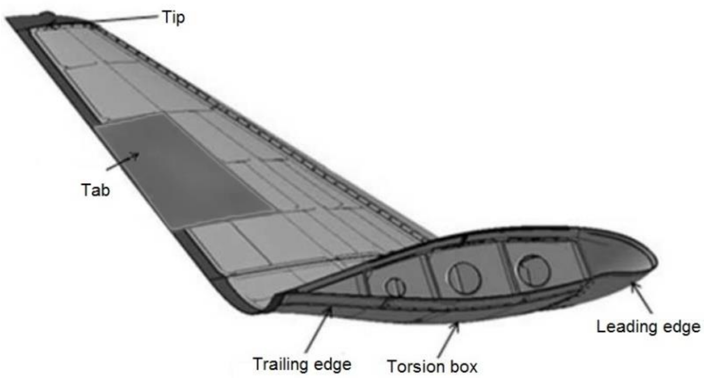


Figure 16: Winglet components

The final requirements, including the manufacturing process of each parts, and features needed for the Prototype Manufacturing tooling will be provided by 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 shall be studied.
Since the CfP covers the tooling for both LH & RH winglets, the use of the same tooling in both of them is desired; therefore the design of versatile modules for both RH & LH winglets shall be valued.
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). Regarding the control and sensor system, simulation studies will be carried out to determine the optimum position of the injection and venting ports and also the distribution of the thermal system and the temperature sensors. Differential systems are foreseeable for both the injection and the heating process. State of the art technology to heat the mould will be addressed.

The Partner shall:

- Propose the most suitable and innovative tooling design for the chosen technology to be applied for each Single Part, including mould, drill, trim, etc. to produce a part according to the drawing set.
- Define and Manufacturing Prototype Tooling for LH & RH that will assure the full functionality of each Single Part and, if needed, modify their designs in order to improve Single Part functionality.
- Define and Manufacturing Prototype Tooling that will assure the demanded quality of each part in accordance with the Technical Specifications.
- 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.
- Delivery of the Prototype Tooling set for manufacturing to the Topic Manager facilities in appropriate transportation means.
- Support 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.
- Identify and report at least the following information: RC, weight (if applicable), materials, manufacturing procedures, LCA data, etc. always establishing the study versus the current solutions applied in industry.

In addition,

- It will be appreciated and desirable that the defined Prototype Tooling could simplify the single part manufacturing process when compared with current tooling systems.
- The implementation, in the Prototype Tooling Design, of innovative and low cost concepts in terms of Materials and Design processes will also be appreciated.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T1	Development and detail design of every tooling needed to manufacture both LH & RH winglets and manufacturing trials	To+6
T2	Manufacture of the tooling	To+12
T3	Validation of the tooling as agreed with the TM (dimensional, air tightness,...)	To+15
T4	Delivery of the manufacturing tooling to the TM facilities and support set up	To+18

Table 7. Partner tasks

The prototype tooling that will be delivered shall have the following properties:

- A self-regulating system with embedded, advanced sensors to monitor the processes at all times (e.g. pressure, temperature, resin flow front, degree of curing, ...)
- Complete and fully operative heating and control systems, including all their components.
- Reduce overall energy consumption by optimizing the cycle and the heating strategy, in particular reducing the resin cure time.
- Surface Quality in accordance with the standards of the Aeronautic Industry.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Trade-offs report: - *Design trade-offs based on TM proposed concepts. Manufacturing approaches for any proposed solution.* - *Materials, RC, Weight, LCA….*	*Report*	To+9
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*	To+15

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D3	Eco-efficient curing system: - *Eco-design and Energy Consumption* - *Thermal Simulation Report*	*Toolings* *Report* *Drawings* *Hardware*	To+15
D4	Final report: Conclusions and lessons learned	*Report*	To+18

Table 8 Major deliverables

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

- Experience in design and manufacturing of manufacturing 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 or later (M), NASTRAN (A), VPM (A)
- Experience in management, coordination and development technological (Aeronautical) programs. (A)
- Proved experience in collaborating with reference aeronautical companies. (A)
- Participation in international R&T projects cooperating with industrial partners, institutions, technology centres, universities and OEMs (Original Equipment Manufacturer). (A)
- 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 manufacturing tooling for components due to manufacturing deviations. (A)
- Experience and know-how with tooling for OoA Technologies (A)
- Advanced Non Destructive Inspection (NDI) and tooling inspection like (A):
    - Dimensional and shaping inspections
    - Morphology studies of materials, if needed.
    - Ultrasonic inspection capabilities.
    - Contactless dimensional inspection systems.
- Simulation and Analysis of Tolerances and PKC/AKC/MKC (Product, and Manufacturing Key Characteristics). (A)

(M) – Mandatory; (A) – Appreciated

VIII. Prototype Tooling for Sub-Assembly, Final Assembly, Functional Checks and Transport of the Morphing Winglet and Multifunctional Outer Flaps of the next generation optimized wing box

<table>
<tr><td>Type of action (RIA or IA)</td><td colspan="3">IA</td></tr>
<tr><td>Programme Area</td><td colspan="3">AIR</td></tr>
<tr><td>Joint Technical Programme (JTP) Ref.</td><td colspan="3">B1.3.1 // B2.2.2</td></tr>
<tr><td>Indicative Funding Topic Value (in k€)</td><td colspan="3">810 k€</td></tr>
<tr><td>Duration of the action (in Months)</td><td>30 months</td><td>Indicative Start Date[33]</td><td>Q1 2017</td></tr>
</table>

<table>
<tr><td>Identification</td><td>Title</td></tr>
<tr><td>JTI-CS2-2016-CFP03-AIR-02-19</td><td>Prototype Tooling for Sub-Assembly, Final Assembly, Functional Checks and Transport of the Morphing Winglet and Multifunctional Outer Flaps of the next generation optimized wing box</td></tr>
<tr><td colspan="2">Short description (3 lines)</td></tr>
<tr><td colspan="2">The aim of this Call for Partner is to develop, design, manufacture and deliver to the Topic Manager, the needed fully functional jigs and tooling to pre-assemble, assemble, eventually enabling performance of some preliminary functional checks and transport components (LH & RH) of the next generation optimized winglet and outer flap.</td></tr>
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[33] The start date corresponds to actual start date with all legal documents in place.

1. Background

The wing is a key contributor to the aircraft efficiency, and the FlightPath 2050 achievement passes necessarily through gains in the wing design targeting all the technological directions: aero-shaping, structural optimisation, system integration, cost effectiveness (manufacturing & assembly), environmental footprint reduction, etc.

For typical regional A/C and small A/C and, in general, as the vehicle MTOW diminishes and the design cruise speed is lower, the wing loading design parameter is much lower, implying that the significance of the structural size of the wing per unit payload is much higher. In addition, the accommodation of other versatile technologies on wing and the cost driver lead the wing box to be of paramount importance for the considered air vehicles in the Technology Stream B-1: Next Generation Optimised Wing Box that is included in the Activity Line B: High Versatility & Cost Efficiency of the AIRFRAME ITD.

The challenge is to develop & demonstrate new wing concepts (including architecture) that will bring significant performance improvements (in drag & weight) while withstanding affordability & environmental stringent constraints withstand.
Two of the main components of the Next Generation Optimised Wing Box (NGOWB) are:

- The Wing Winglets and,
- The Multifunctional Outer Flaps.

The components ready-for-flight will be integrated in the air vehicles with the objective of bringing Technologies to Full Scale Flight Demonstrators levels (TRL 6).

The scope of this call is to obtain sub-assembly, assembly, eventually enabling performance of some preliminary functional checks and transportation tooling to integrate the mentioned components of the NGOWB as end-items and to allow transport them also in a safe way. The sub-assemblies will be performed by the Topic Manager (TM) at their facilities.
The selected partner shall develop, design, manufacture and deliver to the Topic Manager all the prototype tooling in accordance with the technical requirements of the two components, for both LH & RH wing sides, and compatible with the standards for a serial aeronautical production/assembly and transportation.
The Prototype tooling set for sub-assembly and final assembly has to be compliant with the raw materials (Composite and/or Metallic, others…) and manufacturing procedures (OoA, Autoclave, others…) selected by the TM, for both LH & RH wing structural components. Idem for transportation prototype tooling set.

Therefore, the Partner selected for this Call will be the responsible to develop, design, manufacture and deliver all prototype tooling for the sub-assembly and the final assembly of the two mentioned end-items, including all the “secondary toolings“ as drilling templates, locating templates, etc, and the “manipulation tooling“, like work platforms, slings, turning devices, etc, always in accordance with the materials, manufacturing processes and technical specifications selected or developed by

the TM. The same conditions apply for the transportation and enventually preliminary functional checks tooling.
The development of this tooling shall be innovative in order to implement the best performances in the following fields:

- Low Cost / Natural Materials, i.e. applying Additive Manufacturing Techniques,
- Eco-design, i.e. encouraging reusability and recyclability,
- Energy savings,
- Assembly processes simplification and time savings, i.e. implementing gauge-less coordination techniques, developing assembly processes simulations, wireless sensorization of key tooling points, etc.,
- Simplify Transportation processes,

always ensuring that each of the end-items assembled with the prototype tooling fit with the Aeronautical Quality Standards.

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 the NGOWB in the Regional Aircraft FTB2 demonstrator.
The Regional Aircraft FTB2 is a prototype aircraft based on the EADS – CASA (ADSsau) C295 model. This aircraft is Civil FAR 25 certified by FAA and EASA Airworthiness Regulations with large in-service experience as regional aircraft which is a very suitable platform to test in flight Clean Sky 2 mature technologies.

The prototype tooling set for subassembly, assembly, eventual preliminary functional checks and transportation subject to this Cf belong to the wing of the Regional Aircraft FTB2, of reference length 13 m. The main components are shown in Figure 1.

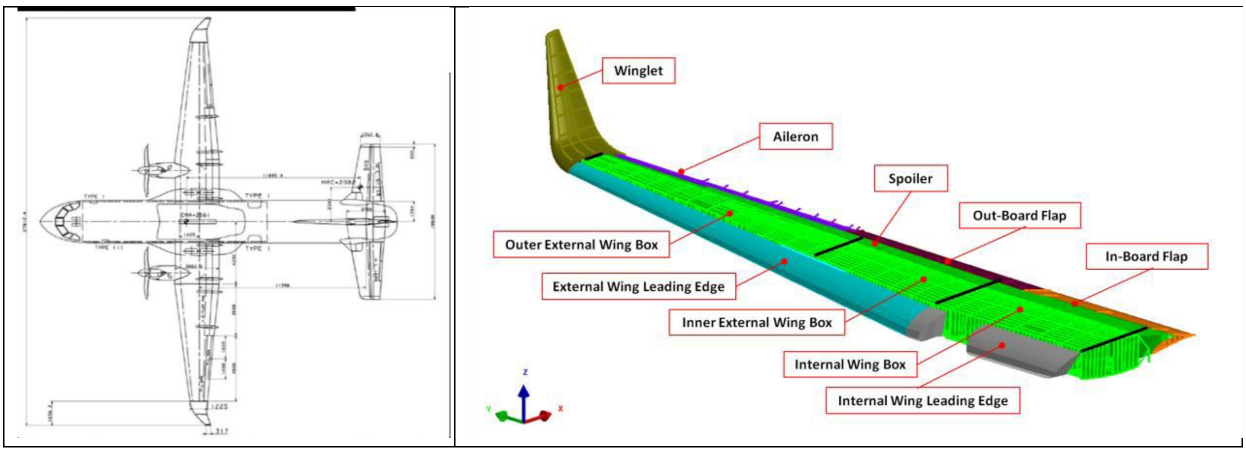


Figure 1. Structural components of the Regional Aircraft FTB2 wing (***)

(***) All the Major parts described, the single parts represented in the figures and the geometries, sizes and shapes of all of them are not frozen and are in accordance with the current design status, as it was mentioned in this document. Other possible configurations could be assessed during the CfP application time and therefore these figures and information are just for a preliminary reference. The final configuration will be frozen in the PDR.

The architecture of the wing is preliminary and may change during the Pre-Design Phase. The Wing design will be frozen at the PDR.

The FTB2 Wing comprises several structural components but the end-items that must be covered by this Call for Partners are:

- LH & RH Morphing Winglets
- LH & RH Multifunctional Outer Flaps.

COMPONENT	**POSSIBLE TECHNOLOGY CHALLENGES OF ASSEMBLY TOOLING**	**DIMENSIONS (**)**	**NUMBER of ELEMENTS**
WINGLET	Reduction of production time, single parts and parts fixation. Integration of the winglets attachments to the wing. Jigless coordination among winglet and wingbox. Low Cost & Eco-Design assuring recyclability and reusability.	Reference dimensions: 1300 x 1500 x 1500 mm	• 1 specimen for "on –ground" static and functional tests • 2 specimens (both wings) ready for flight
MULTIFUNTIONAL OUTER FLAP	Reduction of production time, single parts and parts fixation. Integration of the winglets attachments to the wing. Jigless coordination among winglet and wingbox. Low Cost & Eco-Design assuring recyclability and reusability.	Reference dimensions: 900 x 3500 mm	• 1 specimen for "on –ground" static and functional tests • 2 specimens (both wings) ready for flight

(**)The dimension Included in this Table are approximately. These values will be frozen during Preliminary Design.

The Topic Manager will guide the Partner for the sub-assembly, assembly, eventual preliminary functional checks and transport tooling. The sub-assembly, the assembly, eventual preliminary functional checks and transport tooling for the mentioned components will be delivered to the Topic Manager, that will be responsible for the specimens delivery. All the secondary and manipulation tooling relative to the subassembly, assembly and/or transportation tooling will be delivered at the

Topic Manager facilities.

In general and for info, the conceptual design of every component of the NGOWB will be driven by the Leader in charge of the FTB2while the detailed design; manufacturing and partial assembly (if applicable) will be done by the TM. A high level of concurrent engineering is required all along the project to coordinate design phases, manufacturing, system integration and assembly in "on – ground" and "in – flight" demonstrators. Therefore the same level of concurrent engineering is expected to be achieved between the Partner, the Topic Manager and the Leader for the tasks to be done in common.
The final requirements and features needed for the Prototype Subassembly, Assembly, eventual preliminary functional Checks and Transportation tooling will be provided by TM, at the beginning of the project with the delivery of the Technical Specification for the Tooling.
The Partner will be supported by the TM during the Prototype Tooling Design and Manufacturing phases. The Leader will support them if necessary.

The TM will support the Partner with the following tasks:

- Design Trade-off Studies/Conceptual Studies.
- Material and Production Trade-off Studies for Production process selection.
- Perform Preliminary Design, Sizing and Documentation for Sub-Assemblies and Assemblies just after PDR.
- Test Plan Drafting.
- Assembly Trials Campaign.

The Partner shall:

- Propose the most suitable and innovative assembly process (saving time and energy) for the chosen technology of every Single Part. Each sub-assembly and the final assembly will require all the necessary tooling (jig, drill, lift, etc.) to produce a part in accordance with the drawings. The number of these "secondary tools" should be reduced by an innovative design of the prototype Assembly, preliminary functional Checks and Transportation tooling in order to achieve the already said targets in terms of time and energy reduction.
- Define and Manufacture Prototype Assembly Tooling means that will assure the full functionality of the Sub-Assemblies and the Final Assembly and, if needed, modify the design.
- Define and Manufacture Prototype Transportation Tooling that will assure the full transportability of the end-items in accordance with the technical specification for NGOWB.
- Define and Manufacturing Prototype Assembly Tooling that will assure the demanded Quality of each part in accordance with Technical Specifications.
- Define and Manufacture of all the secondary and manipulation tooling (drilling templates, locating templates, work platform, slings, turning device, etc.) that will be necessary for the subassembly, assembly and transportation processes.
- Generate a tooling documentation in accordance with the Topic Manager specification. This documentation will include, at least, geometrical definition and geometrical control of the

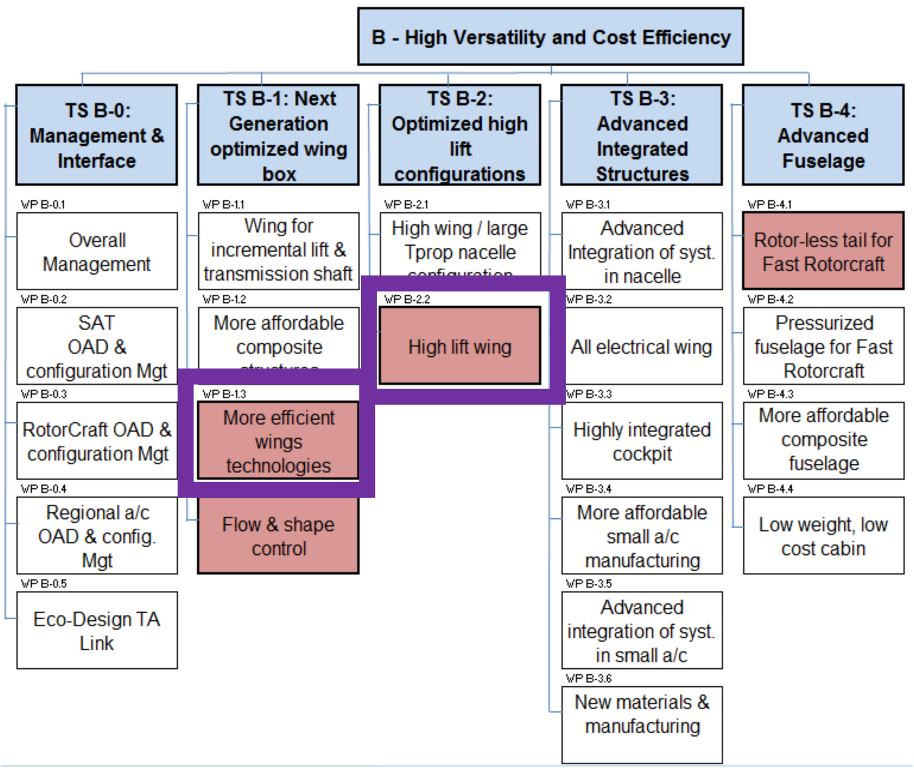
tooling in line with the requirements laid down by the TM. Work with geometrical verification means e.g. laser tracker.

- Delivery of the Prototype Assembly Tooling to the Topic Manager.
- Support the Set up in the Topic Manager facilities in appropriate transportation means.
- Modify the Prototype assembly tooling in accordance with possible single parts design modifications after the Critical Design Review (CDR). Impact limits of this kind of modification (if needed) will be negotiated.
- Follow up of the works performed by the Leader and the TM until the end of the project.
- Identify and report at least the following information: RC, weight (if applicable), materials, manufacturing procedures, LCA data, etc., always establishing the study versus the current solutions applied in industry.

In addition,

- It will be appreciated and desirable if the defined Prototype Tooling could simplify the assembly and transportation process, i.e. being more innovative than the current assembly process.
- The implementation in the Prototype Assembly and Transportation Tooling Design of innovative and low cost concepts in terms of Materials and Design processes will also be appreciated.

By other hand and in order to provide a clear view of the tasks and works to be done by Partner, the WBS for the Demonstration of airframe technologies focused toward High Versatility and Cost Efficiency of Airframe ITD is enclosed.



The Leader and TM will provide the information (design documentation, general requirements specifications, etc) to the partner in accordance with their roles and responsibilities to enable the Partner to perform all relevant tasks related to this CfP. In addition, permanent support to the partner by the TM is envisaged. The following harmonization tasks have to be done before the start of the work:

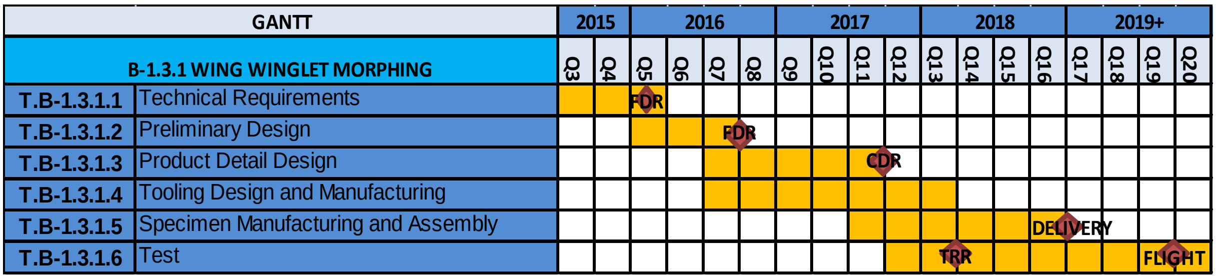
- Method and Tool harmonization (substantiation, IT, Program management)
- Quality assurance process harmonization
- Communication management
- Content of substantiation file (if needed for prototype tooling)

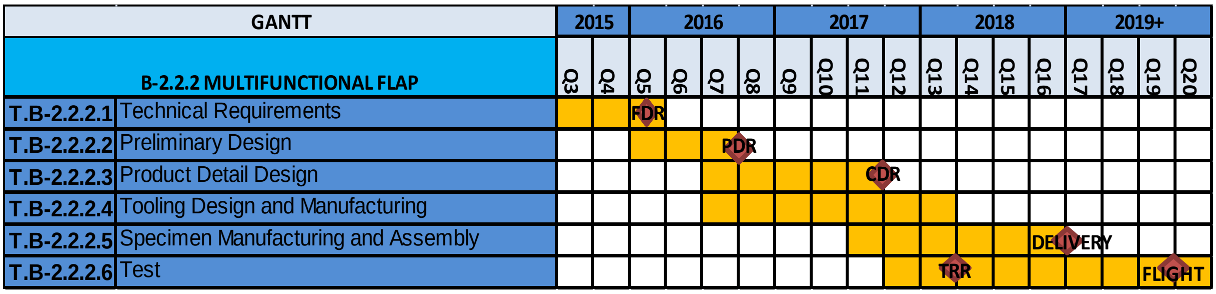
The activities should be structured according to the following list of tasks.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T1	Involvement in Plateau Phase with CoP Design Engineering and Assembly Engineering	T_0 + 4M
T2	Development of Documentation for Tooling Preliminary Design Review (PDR) approval (including drawings, models, reports, FEM Analysis and FEAMs.	T_0 + 6M
T3	Development of Documentation for Tooling Critical Design Review (CDR) approval (including drawings, models, reports, FEM Analysis and FEAMs.	T_0 + 8M
T4	Development and detail design of every tooling needed for the pre-assembly, assembly, preliminary functional checks and transportation of both LH & RH winglets and outer flaps	T_0 + 10M
T5	Manufacture of the tooling	T_0 + 12M
T6	Pre-Ship Acceptance process in accordance with the Topic Manager	T_0 + 13M
T7	Transportation, Delivery and Set-up of all the production tooling to the Topic Manager facilities	T_0 + 14M
T8	Acceptance process in accordance with the Topic Manager	T_0 + 16M
T9	Follow up activities	T_0 + 30M

3. Major deliverables/ Milestones and schedule (estimate)

For information only, the rough planning of both products is shown below in order to keep in mind the main milestones that affect the tooling developoment.





Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
1	**Prototype Assy-Transp. Tooling PDR Documents:** - Prototype Jig & Tooling drawings and models - FEM Analysis - FMEA Analysis	Drawings Models Reports	T_0 + 7M
2	**Prototype Assy-Transp. Tooling CDR Documents:** - Prototype Jig & Tooling drawings and models - FEM Analysis - FMEA Analysis	Drawings Models Reports	T_0 + 9M
3	**Prototype Assy-Transp. Tooling:** - Prototype Jig & Tooling ready to assembly and to transport the produced and assembled components of NGOWB. - Quality inspection reports- CoC - Jig & Tooling Manufacturing Report - Prototype Jig & Tooling Maintenance and Working Orders.	Jig & Tooling Report Drawings Hardware	T_0 + 14M

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***

4	**Prototype Assy-Transp. Tooling Assessments:**
	- Assessment Reports for each Prototype Jig & Tooling about:
	    o Trade off Report
	        ▪ Materials and their manufacturing procedures (if apply), RC, Weight, LCA….
	    o Eco-design and Energy Consumption
	    o Thermal Simulation Report
	- Final Report with Conclusions and Lessons Learned.
		Report	T_0 + 14M

5	**Follow up Activities:** - Design documents, 3D models, Jig & Tooling manufacturing reports etc… (Idem than Deliverable nº1&2) for possible modifications during follow up phase	Jig & Tooling Report Drawings Hardware	T_0 +30M

*T_0 Is the starting date of the activities to be performed by the applicant.

In the table, PDR and CDR refer to the Tooling and thus to the activity to be performed by the Partner.

Inputs to be delivered by TM to Partner			
Ref. No.	***Title - Description***	***Type***	***Due Date***
1	Technical documentation from Components PDR: - CATIA Models and drawings from PDR - Tooling Technical Specification	Report Drawings Models	T_0
2	Assembly Processes: - Proposed materials and assembly processes	Report or others	T_0
3	Technical documentation from Components CDR: - CATIA Models and drawings from CDR	Report Drawings Models	T_0 + 8M

*T_0 Is the starting date of the activities to be performed by the applicant.

In the table, PDR and CDR refer to the Component and thus to the activity to be performed by the ITD Airframe member in charge of the component.

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

(M) – Mandatory; (A) Appreciated

- Experience in design and manufacturing of assembly tooling for structures in non-conventional and conventional composite materials (thermoset and thermoplastic –regular and high temperature conditions-) and innovative metallic components. (M)
- Design and analysis tools of the aeronautical industry: i.e. CATIA v5 r21 or later (M), NASTRAN (A), VPM (A).
- Experience in management, coordination and development technological (Aeronautical) programs. (A)
- Proved experience in collaborating with reference aeronautical companies with industrial air vehicle developments with "in – flight" components experience. (M)
- Participation in international R&T projects cooperating with industrial partners, institutions, technology centres, universities and OEMs (Original Equipment Manufacturer). (A)
- Competence in management of complex projects of research and manufacturing technologies. (A)
- Experience in the following fields:
  - Assembly (M)
  - Process Automation (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 assembly tooling due to manufacturing deviations. (M)
- Qualification as strategic supplier of assembly tooling on aeronautical elements. (M)
- Knowledge and experience in suitable technologies for aeronautical parts: positioning system, drilling, riveting, functional checks and handling. (M)
- Advanced Non Destructive Inspection (NDI) and tooling inspection like:
  - Laser Tracker Measurements and Inspections (M)
  - Morphology studies of materials-if needed. (A)
  - Welding inspection (A)
- Contactless dimensional inspection systems. (A)
- Simulation and Analysis of Tolerances and PKC/AKC/MKC (Product, and Manufacturing Key Characteristics). (A)
- Into the eco design field, the Partner shall have the Capability to monitor and decrease the use of hazardous substances regarding REACH regulation (A).

It is expected, that only technologies which are at TRL4 will be proposed for the prototype innovative assembly and transportation tooling.

5. Abbreviations

TRL	Technology Readiness Level	M&A	Mounting and Assembly
OoA	Out of Autoclave	QG	Quality Gate
RTM	Resin Transfer Molding	R/C	Rotor Craft
SQRTM	Same Qualified Resin Transfer Moulding	RRs	Roles and Responsibilities
LRI	Liquid Resin Infusion	TBC	To Be Confirmed
IR	Infra Red	TBD	To Be Defined
XCT	X-ray Computerized Tomography	VS	Vertical Stabilizer
POA	Production Organization Approval	WBS	Work Breakdown Structure
DOA	Design Organization Approval	WP	Work Package
EASA	European Aviation of Safety Agency	COS	Conditions of Supply
FAA	Federal Aviation Administration	SPC	Super Plastic Forming
LCA	Life Cycle Analysis	ALM	Additive Layer Manufacturing
LCCA	Life Cycle Cost Analysis	AHE	Airbus Helicopters Spain
OEM	Original Equipment Manufacturer	CfP	Call for Partner
R&T	Research and Technology	CI	Configuration Items
NDI	Non Destructive Inspection	HS	Horizontal Stabilizer
IP	Intellectual Property	HVE	High Versatility and Cost Efficiency
CoP	Core Partner	IAW	In Accordance With
ISC	In-Situ Co-consolidation	ITD	Integrated Technology Demonstrator
WAL	Work Area Leader	JTP	Joint Technical Proposal
SMR	Structural Manufacturing Responsible	SDR	Structural Design Responsible
CS	Control Surfaces	NGOWB	Next Generation Optimised Wing Box
PDR	Preliminary Design Review	CDR	Critical Design Review
TM	Topic Manager		

IX. Low cost Fused Filament Fabrication of high performance thermoplastics for structural applications

Type of action (RIA or IA)	RIA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	WP B-1.4		
Indicative Funding Topic Value (in k€)	350 k€		
Duration of the action (in Months)	24 months	**Indicative Start Date**[34]	Q1 2017

Identification	Title
JTI-CS2-2016-CFP03-AIR-02-20	**Low cost Fused Filament Fabrication of high performance thermoplastics for structural applications**
Short description (3 lines)	
The objective is to apply and mature Fused Filament Fabrication (FFF) for the design and manufacturing of actuators dedicated to flow separation control. The actuator concept is characterized by having no moving parts and as such being highly robust. Installation constraints on aircraft level require structural integrity up to 200°C.	

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

1. Background

Current concept foresee titanium (machined or 3D printed) as standard material for pulsed jet actuators (PJA) for active flow control (AFC). Titanium provides the required material properties for the application temperature of around 200°C. The designed parts can also be load carrying due to the mechanical properties of titanium even at higher temperatures. However, titanium 3D printed or machined parts are expensive to produce and are fairly heavy (density 4.5 g/cm3).

Instead, the actuators may be produced using high performance thermoplastics. These provide a substantial weight benefit, as an example PEEK only features a density of 1.3 g/cm3. Furthermore this material features more favourable temperature characteristics, e.g. thermal insulation and dilatation coefficient.

With respect to development and low volume production, 3D printing is a very promising manufacturing method due to the added design flexibility and no need for complex and costly moulding tools.

Printing technical thermoplastics with laser sintering methods (SLS) is state of the art. Using the more advanced FFF method (Fused Filament Fabrication) requires substantial development but also brings various benefits. FFF deploys simple machine setups and low cost materials hence reducing the overall manufacturing costs. However, FFF printing high performance thermoplastics is not yet state of the art.

Substantial research is required to find stable process parameters (e.g. print speed) and temperatures. Printing high performance thermoplastics requires very high temperatures (~400°C). These can lead to thermal stresses in the produced parts. The entire process needs to be stabilized and monitored. In addition all process parameters need to be optimized for best part quality, mechanical properties and reproducibility. The FFF process also enables the integration of reinforcement fibers, hence providing a unique selling proposition in terms structural performance. Further research needs to be conducted for the introduction of various types of reinforcement fibers.

The objective of the topic is to develop the FFF process to 3D print high performance thermoplastics for producing pulsed jet actuators. The developed process must ensure that the actuators withstand the structural loads even at high temperatures. The parts must also be reproducible with the required quality.

2. Scope of work

The partner will receive geometrical data and preliminary specifications from the Topic Manager. The specifications include amongst others surface roughness, operation temperature, structural strength etc. The requirements are subject to ongoing research within CS2 and will be finalized during the course of the project.

Based on the specifications, the partner shall develop fully operational printers including both hardware and software. These machines shall be continuously improved based on the gained experience and also have to produce test specimens and prototypes.

As a final step the applicant shall work out how to deploy the FFF process on an industrial aerospace level for the specified application. Important aspects of the investigation are process monitoring, lead time and production costs per unit.

The following tasks are to be performed by the Partner:

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T1	Development of a PEEK capable FFF printer according to the preliminary specifications	M10
T2	Development of updated PEEK FFF printer according to the final specifications	M20
T3	Translate lessons learned to a possible industrial setup for serial production of FFF manufactured PEEK parts	M24

Task 1: Development of a PEEK capable FFF printer according to the preliminary specifications

The partner needs to develop functional prototype printers capable to fabricate components using technical thermoplastics such as PEEK with the FFF method. It is estimated that several machines have to be built. This way test benches for iterative improvements will be available while maintaining operational capabilities for the required test program. The printer has to include a heated build volume with controllable temperature. The maximum achievable and stable temperature should be 150°C (printer version 1- V1). At least one V1 shall be provided to the Topic Manager for testing and assessment.

The partner shall use the machine to produce small test coupons (max. 100x100x100 mm) for material characterisation (structural, thermal, and functional testing). This testing will be conducted by the Topic Manager. Coupon geometry will be specified by the Topic Manager and will be based on new test methods to characterize the critical material properties. The partner needs to incorporate design improvements for V1 in a constant exchange with the Topic Manager.

Task 2: Development of updated PEEK FFF printer according to the final specifications

Based on the results from the prototype printer V1, an updated and improved version shall be produced and delivered (V2). V2 shall be capable of repeatedly printing larger components (roughly 230x220x200 mm) with the required accuracy and quality as specified under section 4. In contrast to V1, a slightly higher build volume temperature may be required. This needs to be taken into account by the partner since this will directly influence the design of the printer. Final build volume temperature will be a result of Task 1 and will be specified by the Topic Manager in exchange with the partner.

A specific use case is the full scale pulsed jet actuator. The partner needs to prove the capability of the printer V2 to produce the actuator repeatedly for assembly and structural testing. In addition several other components, such as flow control system components, dividers and adapters should be printed and provided to the Topic Manager to allow the assessment of the flexibility of the developed process and machines to extend it to manufacture other types of components

The manufactured components have to be provided to the Topic Manager for structural, thermal, aerodynamic and functional testing. At least one V2 shall be provided to the Topic Manager for testing and assessment.

Task 3: Translate lessons learned to a possible industrial setup

In an industrial environment, it is likely that a large number of printers are clustered in so called 'print hubs'. It is hence important to investigate how these machines can operate in such an environment, with respect to quality/ process monitoring and general operational aspects. The operation and control of all machines shall preferably be centralized.

The Topic Manager will provide the boundary conditions of such an environment (i.e. production rate, target cost etc.). Based on that data the partner needs to conceptually show the capability of the type V2 printer to operate efficiently in the specified environment. A comparable baseline will be provided by the Topic Manager.

3. Major deliverables/ Milestones and schedule (estimate)

Major deliverables and milestones are summarized on the following tables:

Deliverables			
Ref. No.	*Title - Description*	*Type*	*Due Date*
D.1	Delivery of operational FFF PEEK prototype printer including a delivery report	Report/ Hardware	M9
D.2	Delivery of final FFF PEEK printer including a delivery report	Report/ Hardware	M18
D.3	Concept of industrial setup for serial production	Report	M22
D.4	Final report	Report	M24

Milestones		
Ref. No.	*Title - Description*	*Due Date*
M1	PDR of FFF prototype PEEK printer	M3
M2	CDR of FFF prototype PEEK printer	M6
M3	PDR of final FFFPEEK printer	M12
M4	CDR of final FFF PEEK printer	M15
M5	Intermediate progress review of concept analysis of industrial setup	M20

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

Skills

The applicant shall have expertise and capabilities with the development of low cost FFF 3D printers.

The applicant shall have expertise setting up FFF printers in an industrial environment; i.e. multiple printers operating simultaneously in a so called print 'hub'

The applicant shall have expertise with the development of printer firmware and software.

The applicant shall have experience with state of the art FFF printers and use those as a bench mark for printing high performance thermoplastics.

The applicant shall be able to specify required material modifications for the best possible print quality.

Hardware/ Software requirements

The following requirements have been specified:

- The approach should be scalable (in terms production rate) to industrial level
- Build volume min. 230x220x200 mm (width x depth x height) and scalable
- Print material validation coupons, iterative for process monitoring (quality assurance, sensitivity of process regarding material and process parameters)
- Print prototype actuator for system testing
- In a first step prototypes may be printed with low end materials such as ABS (preferably on the same machine)
- Comparable print performance in terms of surface quality to commercially available machines in the 2k-3k€ range (min layer thickness, etc.)
- Heated build volume will be required for high performance thermoplastics and the development shall be part of the project
- High demands for dimensional accuracy (machine repeatability & low thermal deformation) and low thermal stresses
    - Dimensional accuracy in plane 0.05mm
    - Hence reduced temperature gradients below glass transition temp. (uniform temperature distribution)
    - Cooling; controllable and uniform cooling rate of finished part in order to avoid

thermal stresses

- Performance
  - Min 50 mm/s 0.4mm nozzle.
  - Nozzle diameter and shape to be investigated and optimized for pulsed jet actuator
  - Bed material needs to be developed to guarantee good bed adhesion
- Easy maintainability of the prototype printer is required, hence; fast replacement of primary wear and tear parts (nozzle, etc.)
- Possible aspects regarding quality assurance are in line process monitoring (remote access, etc.)
- The software (Gcode/ numerical control (NC) programming language)/ firmware development should also be mastered by the applicant since they are an integral part of the entire process
- Appropriate print parameters and strategies need to be developed for the printer using high performance thermoplastics (print speed, temperatures, etc.)

X. Innovative Tooling Design and Manufacturing for Thermoplastic Stringers and High Integration

Type of action (RIA or IA)	IA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	WP B-1.4.2 / B-2.2.1		
Indicative Funding Topic Value (in k€)	1200 k€		
Duration of the action (in Months)	10 months	Indicative Start Date[35]	Q1 2017

Identification	Title
JTI-CS2-2016-CFP03-AIR-02-21	Innovative Tooling Design and Manufacturing for Thermoplastic Stringers and High Integration
Short description (3 lines)	
The CFP is oriented to deliver methods and innovative moulds for thermoplastic technologies applied to aerospace parts with PEEK-carbon fiber. Activities will be focused in continuous manufacture of shaped profiles ("omega" and "T" stringers) of 4meters allowing accommodate thickness changes for joggles and ply drop-offs in the skins. The subsequent activity will be design and manufacturing of moulds for the integration of both components by in-situ consolidation. Creative solutions incorporating flexibility and new materials facilitating heat transfer, vacuum application and lamination by automated fibre placement are required.	

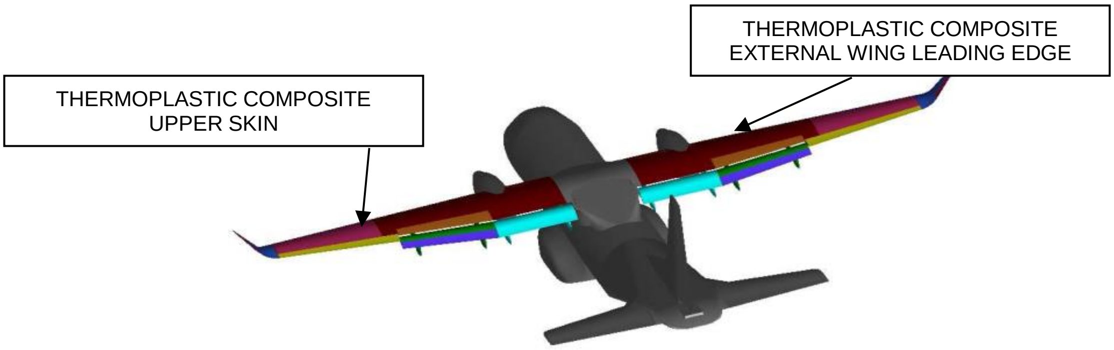
[35] The start date corresponds to actual start date with all legal documents in place.

1. Background

Specific thermoplastic material, such as **PEEK**, with continuous fibre reinforced can provide improved performance to epoxies; these materials are easily recycled and have an excellent fatigue and impact behaviour, as well as, better damage tolerance, being the most suitable material for primary structure applications. Thermoplastic (PEEK) resins offer a high potential not only regarding material properties, but also in order to reduce processing, logistic, operation and life cycle cost.

From a manufacturing point of view, the Topic Manager (TM) has developed a thermoplastic fibre placement technology based on laser beam heating that enables **in-situ consolidation** (ISC) of thermoplastic material out of the autoclave. The aim of in situ consolidation process is key to achieve a cured final structure, with a reduction of production costs and autoclave use, and permits the creation of components quickly and more efficiently

Technologies such as, manufacture continuous stiffeners and integration of structures by automated fibre placement of thermoplastic composite allow to achieve high technological level, producing with highly automated manufacturing process and without high energy consumption during the process. Both technologies will be used to manufacture an upper skin and an external wing leading edge.



Into de ITD Airframe part B the call for proposal is linked to B1.1.4/B2.2.1_(TASK 1.5) -INNOVATIVE CONCEPTS UP TOOLING- Two main technology drivers are aimed in this proposal.
The first one is oriented to design and manufacturing tooling concepts with innovate solution to facilitate the heat transfer, first ply position and full integration of different shape by co-consolidation method for flat, contoured and full integration panels for upper skin and a leading edge.
The second will be focused on design and manufacturing a new concept of thermoforming tooling machine capable to produce continuous stringer of 4 meters with variable shape to adapt skin inner geometry.

The Topic Manager will define the necessary material data for a proper design and manufacturing tooling:

- The final stringer geometry to design the new concept of continuous moulding for shaped T and Omega profiles

- Conceptual mould design for wing skin and leading edge panels.

2. Scope of work

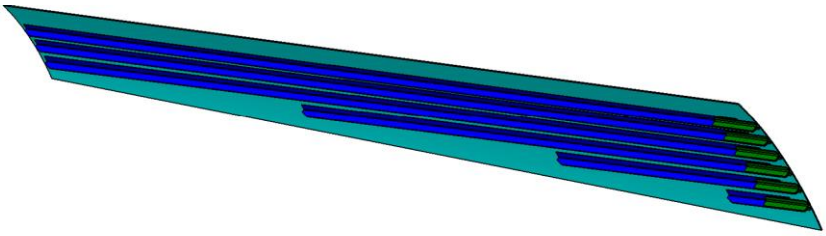
Low Cost Innovative Modular System To Integrate Complex Thermoplastic Structures

In the frame of in situ consolidation technology in order to manufacture thermoplastic composite parts with high level of integration, the first activity to be performed will be oriented on the design and manufacturing of an innovative and low cost tooling with several moulds for the integration of both components, stringers and skin by in-situ consolidation. Two modular systems will be designed and manufactured; one of them for an upper wing skin and the second one for an integration of an external leading edge.
Innovative solutions incorporating flexibility and new materials facilitating heat transfer, vacuum application and lamination by automated fibre placement are required.

During manufacturing process, laminate is subjected to several heating and cooling cycles which will result in residual stresses inside final laminates. In order to eliminate this issue, a self-heated mould will be used during the whole time when the material is deposited; the temperature of the mould will be around 250ºC-300ºC. It will be necessary to carry out a study of different heating system (electrical resistance, oil, etc.) and a thermal study between the different parts of the full integration moulds.

Modular tooling enables the use of interchangeable moulds. To facilitate demoulding process it is necessary to use innovative materials to keep the integrity of the structure. As well it is essential to develop a system to locate the first layer correctly in a modular tooling, at least with double curvature.

The challenge is to develop a modular system mould to integrate complex thermoplastic parts in one step without the use of the autoclave. The dimensions of tooling for upper skin approximately will be 5000x2000 mm; initial structural scheme design will incorporate six stringers.



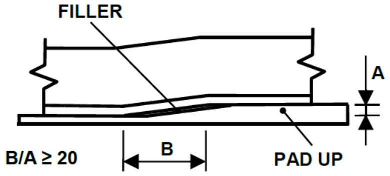
The dimensions of tooling for the leading edge will approximately be 3000x700 mm. The initial structural scheme design will incorporate 4 stringers.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T1	Conceptual design specification of full integration mould for upper skin and leading edge: - *To define the conceptual design* - *To define the requirements and technical specification for the upper skin mould* - *To define the requirements and technical specification for the external leading edge mould*	T_0+2
T2	Final design of full integration mould for upper skin (symmetric and drawing mould): - *Design all the systems of the integration mould to manufacture the upper skin.*	T_0+4
T3	Manufacturing full integration mould for upper skin (symmetric and drawing mould)	T_0+10
T4	Final design of full integration mould for leading edge: - *Design all the systems of the integration mould to manufacture the external leading edge.*	T_0+3
T5	Manufacturing full integration mould for leading edge	T_0+10

<u>Thermoforming Equipment To Manufacture Continuous Stringers With Two Different Shape "Omega" And "T" Profile</u>

The main goal is the design and manufacturing of a continuous thermoforming system to manufacture stiffeners with high performance thermoplastic composites; continuous unidirectional fibre, woven and PEEK resin. The melting temperature of this thermoplastic is 350ºC. The thermoforming equipment will have to manufacture two types of stringers: T and omega profiles.

Not only the design and manufacture of the continuous system will be required, but also the parameters set up to reach results in very high-quality composites and the manufacturing of both types of stringers, T profile and omega, with no wrinkling even on complicates geometries such as thickness changes for joggles and ply drop offs, through mechanical and physical samples test.



The continuous thermoforming machine will incorporate all the process steps in a single machine to provide the most suitable solution to manufacture different shaped profiles and the ability to produce continuous thermoplastic composite structural components made with continuous carbon fibre and PEEK thermoplastic resin.

Several systems and variables must be considered in the automated production of profiles:

- The type of material to be formed.
- Infra-red (or another system) heating system for the blanket.
- Self-heating moulds (resistant, mineral oil, etc.).
- Pressure system.
- Cooling temperature control accuracy
- Process time.
- Insulation

The best option will be developed to make different shape of PEEK composite materials. The process must offer the advantages inherent in a continuous manufactures process that produce complex components in short time and optimize the design to avoid the wrinkling in the continuous process.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T6	Conceptual design specification continuous forming equipment for stringers: - *To define the conceptual design* - *To define the requirements and technical specification for the process* - *To determinate the parameters to be taken into account to assess the performances of process to manufacture a T profile* - *To determinate the parameters to be taken into account to assess the performances of process to manufacture an omega profile*	T_0+2
T7	Final design continuous forming equipment for stringers - Design all the systems of the continuous forming equipment with the different parts to manufacture two types of stringers.	T_0+3
T8	Manufacturing continuous forming equipment for stringers - Manufacture the continuous forming equipment to manufacture T profiles and omegas.	T_0+9
T9	Manufacture 10 T profiles by continuous forming process Manufacture 10 omega profiles by continuous forming process	T_0+10

3. Major deliverables/ Milestones and schedule

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Conceptual design specification of full integration mould for upper skin and leading edge	Report	T_0+2
D2	Final design of full integration mould for upper skin (symmetric and drawing mould)	Catia and drawing	T_0+3
D3	Manufacturing full integration mould for upper skin (symmetric and drawing mould)	Tooling	T_0+10
D4	Final design of full integration mould for leading edge	Catia and drawing	T_0+3
D5	Manufacturing full integration mould for leading edge	Tooling	T_0+10
D6	Conceptual design specification continuous forming equipment for stringers	Report	T_0+2
D7	Final design continuous forming equipment for stringers	Catia and drawing	T_0+3
D8	Manufacturing continuous forming equipment for stringers	Tooling	T_0+9
D9	Manufacture 10 T profiles by continuous forming process Manufacture 10 omegas by continuous forming process	T Profiles and omegas	T_0+10

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Final design of full integration mould for upper skin and leading edge	Catia and drawing	T_0+3
M2	Final design thermoforming mould for stringers and leading edge	Catia and drawing	T_0+3
M3	Manufacturing full integration mould for upper skin and leading edge.	Tooling	T_0+10
M4	Manufacturing continuous forming equipment	Tooling	T_0+10

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

- ✓ Expert on tooling design and manufacture for thermoplastic fibre placement technology based on laser beam heating that enables in-situ consolidation
- ✓ Aeronautical specifications knowledge
- ✓ Design of self-heating moulds
- ✓ Expertise on manufacturing of complex shapes and frames for aeronautical components
- ✓ User of NDT techniques, such as ultrasonic and/or tomography

XI. Adaptive multifunctional innovative Test Rigs for both structural test of multidimensional and multishape panels and structural tests on Tail unit

Type of action (RIA or IA)	IA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	WP B-2.2.2. / WP B-4.1.		
Indicative Funding Topic Value (in k€)	350 k€		
Duration of the action (in Months)	18 months	**Indicative Start Date**[36]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-AIR-02-22	**Adaptive multifunctional innovative Test Rigs for both structural test of multidimensional and multishape panels and structural tests on Tail unit**
Short description (3 lines)	
The aim of this Call is to design, manufacture and delivery to the Topic Manager adaptive multifunctional innovative Test Rigs for both structural test of multidimensional and multishape panels, and structural tests on Tail unit.	

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

1. Background

The work to be performed by the Topic Manager (TM) in Airframe ITD aims at developing, designing, manufacturing and partially assembling different lightweight structural components of Regional Aircraft FTB2 wing and LifeRCraft tail unit “on-ground” and “in-flight” demonstrators.

The Topic Manager will develop and provide new architectures to host complex integrated systems based on state of the art out of autoclave composite manufacturing and metallic technologies with special focus on process automation, but will also develop innovative composite and metallic materials and processes.
WP B-2.2.2 aims to the testing of structural detail test panels build in previous stages. To validate the new development, structural tests will be carried out for material characterization and panel type tests. For those tests, advanced instrumentation sensors and systems can be used to check and monitor the structural behaviour of these specimens during the test.

WP B-4.1 will be focused on the execution of the tests with special attention on the tail cone Full Scale test. Correlation with theoretical analyses will be carried on, validating compliance with structural requirements ensuring the permit to flight. A test plan definition will be carried out. This test plan will define the Ground Structural Tests that are needed to be committed, as well as the procedures that have to be followed. Once the test plan is approved, the following tasks have to be accomplished: design and manufacture a dedicated test bench, define the load application, define the specimen monitoring during the test. Finally, a deliverable will resume the results of the carried out tests.

Technical Objectives

WP B-2.2.2: FTB2-Outer External Wing – Upper Skin and External Wing Leading Edge

- To develop a novel in-situ consolidation and co-consolidation technology in order to manufacture using automated technologies thermoplastic composite parts with high level of integration,
- To obtain a design guide to support the structural design, tailored stiffness for morphing characteristics and crashworthiness or bird impact behaviour of this kind of structures.
- To produce a tailored co-consolidated stiffened upper skin and an external wing leading edge in thermoplastic composite material using out of autoclave automated lamination and consolidation technology for improving structure maintenance and reparability, reducing production and assembly time and reducing manufacturing costs and energetic costs by the removal of the autoclave in the process.
- To incorporate new non-destructive inspection techniques, such as IR-Thermography and ultrasonic phased array including flexible encoders for automatic evaluation of such innovative structures and materials.

WP B-4.1: Rotorless Tail for LifeRCraft

- To develop, design, manufacture, verify and validate a highly integrated composite tail unit structure manufactured with innovative automated out of autoclave manufacturing processes (including additive manufactured secondary structure fittings) that:
  1. meets weight targets,
  2. reduces manufacturing time and costs vs current tail unit structures
  3. enables improved helicopter performance.
- To carry out structural test to validate the Tail.

The Partner that will be selected for this Call, will be responsible for the design in collaboration with TM, manufacturing and delivery to the TM of the required multifunctional and innovative test benches for performing the required structural tests for each of the above described WPs.

2. Scope of work

FTB2-Outer External Wing – Upper Skin and External Wing Leading Edge

Tasks		
Ref. No.	***Title - Description***	***Due Date***
1	Adaptive multifunctional innovative test rig design and manufacturing.	T0+18

Rotorless Tail for LifeRCraft

Tasks		
Ref. No.	***Title - Description***	***Due Date***
2	Adaptive multifunctional innovative test rig design and manufacturing.	T0+18

The aim is to design, manufacture and delivery adaptive multifunctional innovative Test Rigs built-in high performance instrumentation for both structural test of multidimensional and multishape panels and structural tests on Tail unit. These structures monitoring and adaptability implies an innovative and transversal design of those elements, that implies knowledge and expertise from various sections involved, and also an accurate manufacturing, with high quality standards aiming at the objective of reducing the difficulties for the preparation and assembly at different multifunctional testing benches.

The conceptual and detailed design of test benches will be driven by Topic Manager in close collaboration with Partner, while the manufacturing will be done exclusively by the Partner.
A high level of concurrent engineering is required all along the project to coordinate design phases and manufacturing for both test benches.
Topic manager will provide enough information (design documentation, general requirements specification,…) prepared by platform Leaders, depending on the related WP, and Topic Manager which will enable the Partner

to master the tasks that are described into this document. Permanent support of Topic Manager is envisaged.
The Partner shall be able to:

- propose the most suitable and innovative tooling designs ad manufacturing process.
- generate tooling documentation according with Topic Manager specifications. This documentation will include, at least, geometrical dimension and tolerances control and verification (laser tracker, tri-dimensional reports, etc.), welding certification, etc.
- delivery to Topic Manager the test benches tooling elements together with assembly procedure documentation so as to allow the TM to assemble the targeted structures.

3. Major deliverables/ Milestones and schedule (estimate)

WP B-2.2.2: FTB2-Outer External Wing – Upper Skin and External Wing Leading Edge

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
1	Designed test rig models and documentation - *Technical documentation. Preliminary Review.* - *CATIA Models. Preliminary Review.*	Models Report	T0+9
2	Designed test rig drawings/models and documentation - *Technical documentation. Preliminary Review.* - *CATIA Models and drawings. Detailed design review.*	Drawings/Models Report	T0+12
3	Test rig delivery according to specifications.	Tooling Report	T0+18

WP B-4.1: Rotorless Tail for LifeRCraft

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
4	Designed test rig models and documentation - *Technical documentation. Preliminary Review.* - *CATIA Models. Preliminary Review.*	Models Report	T0+9
5	Designed test rig drawings/models and documentation - *Technical documentation. Detailed design review.* - *CATIA Models and drawings. Detailed design review.*	Drawings/Models Report	T0+12
6	Test rig delivery according to specifications.	Tooling Report	T0+18

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

- ✓ Experience in design and manufacturing of test bench structures in metallic components. (M).
- ✓ Design and Analysis tools of the aeronautical industry (i.e. CATIA v5 R21). (M).
- ✓ Competence in management of complex projects of research and manufacturing. (M).
- ✓ Proved experience in collaborating with reference aeronautical test laboratories during test bench design and manufacturing processes at development/certification testing programs for reference aeronautical companies. (M).
- ✓ Participation in international R&T projects cooperating with technologies centres. (A)
- ✓ Capacity to support documentation and means of compliance to achieve required specifications. (A)
- ✓ Experience in the following fields:
    - Multifunctional test bench design process. (M).
    - Manufacturing process. (A).
    - Test benches preparation for high performance instrumentation installation and monitoring. (M).
- ✓ Quality System International Standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004). (M).
- ✓ Qualification as strategic supplier for aeronautical testing laboratories. (M).
- ✓ Experience and know-how with metallic tooling manufacturing. (A).
- ✓ Experience in management and development technological programs. (M).

(M) - Mandatory; (A) - Appreciated.

XII. Automation of hand lay-up manufacturing process for composite stiffeners

Type of action (RIA or IA)	IA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	WP B-3.6		
Indicative Funding Topic Value (in k€)	120 k€		
Duration of the action (in Months)	12 months	**Indicative Start Date**[37]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-AIR-02-23	**Automation of hand lay-up manufacturing process for composite stiffeners**
Short description (3 lines)	
The target of the work is to set up technical specification for the implementation of advanced equipment to automate or assist the manufacturing process of hand lay-up of Carbon Fiber Composite stiffeners with omega section, and to realize the trials.	

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

1. Background

Clean Sky 2 will deliver break-through technologies for incorporation into the next generations of aircraft from 2025 onwards. By spearheading European aeronautics research culminating in demonstrations of game-changing new vehicle configurations, Clean Sky 2 will enable the aeronautics industry to introduce innovations in timescales that would otherwise be unachievable. In so doing, it will drive environmental improvements, increase transport efficiency, and create jobs and growth for Europe

The framework of this topic is Clean Sky 2 Airframe *Work Package B-3.6: "New Materials and Manufacturing Technologies"*.

The topic deals with manufacturing techniques of composite parts by automatic procedures.
Composite structures consist on integrated parts, skin and stiffeners. These parts present flat and curved geometries combined different manufacturing technologies, cured and semi-cured parts. Concerning the manufacturing of the skin, in the last few years, it has progressively been automated, improving the manufacturing rates as well as upgrading industrial means. Nevertheless, stiffeners are mostly manufactured by hand-lay- up. Since current monolithic designs are based on the integration of skins and stiffeners, a step change is becoming mandatory to transform hand lay-up manufacturing into assisted and/or automated alternative processes also for stiffeners.

The Topic Manager is currently promoting synergic initiatives to achieve highly efficient manufacturing systems, beyond low cost initiatives just based on procurement approaches and hand lay-up labor costs.

2. Scope of work

The objective of the work is to set up the technical specifications and requirements of the equipment needed for testing and also, the definition, planning and execution of the tests to be carried out at laboratory level and industrial level.

The activities proposed are focused on (for the work packages under CfP responsibility):

- Definition of the set of equipment for laboratory
- Test preparation, including testing tools.
- Development of test procedures based on defined test, planning and execution of the tests at laboratory and Aircraft configuration. All results will be downloaded into a suitable tool ready to consult and extract data of those tests.
- Delivery of reports with all the results obtained and conclusions.

The testing activity must be based on implementation of advanced equipment to shift hand into automated/assisted lay up of flat and curved panels used on pressurized aero-structures based on thermosetting prepregs and infusion technologies.

Feedback to the Topic Manager must be provided as potential economic advantages and long term roadmap.

Appropriate skills for pressurization tests, aircraft systems installation (fuel systems, fuel tanks, and pneumatic systems), composite materials & processes and robotized and assisted manufacturing automation are required for tests preparation and tests execution.

WP1. Definition of Laboratory Cell for trials

First of all, the Topic Manager will define the stiffener selected to perform the manufacturing system. The design of the parts to be studied will be part of this work. It consists of a stacked sequence of plies, usually obtained from a nesting configuration in an automated cutting machine. The plies can be made from prepregs or dry fabric rolls. Different values of curvature shall be also taken into account, in order to define a flexible lay-up cell, permitting a geometry window able to fulfil a parametric approach for different stiffener sizes. The definition of the manufacturing process shall include the applicable raw materials as well as the ancillary ones to be used. The Topic Manager qualified materials shall be used.

The resulting cell shall respect the qualified in standards procedures, unless major advantages could arise and further improvements to be proposed, accepted and approved by potential update of reference normative. To ensure the manufacturing of parts without non-quality issues, following the Topic Manager standards such as I+D-P 233 and 80–T–31–2919 ("Manufacture of Monolithic Components by Means of Modified Vacuum Infusion Process (MVI Process)").

The selected manufacturing process will have a special zoom dedicated to the lay-up operation, main objective of the automated/assisted activity to be developed in the laboratory cell. It will combine existing industrial means and a device or equipment representative of the automated/assisted lay-up system.

The requirement will be to compare the work performed with current robots within Industrial Cell in order to study the feasibility of collaborative robots for the same manufacturing process. The main objective is to automate the process using collaborative robots.

The cell for trials shall be developed to operate within a Clean Area, in accordance with aeronautical composite manufacturing processes. The trial cell will be defined by means of a written specification which shall be approved by the Topic Manager.

Two main milestones will be accomplished: Preliminary Design Review (PDR) and Critical Design review (CDR). The PDR will contain the proposal of the cell for trial. Once the concept is approved by the Topic Manager, the cell will be designed. The CDR will validate the design and constitute the starting point of the manufacturing and integration of the cell for trials, whose device for lay-up and compaction is the main objective of this work.

WP2. Implementation of Laboratory Cell for trials

Once the cell for trials has been design and delivered, it will be implemented within an industrial environment, complemented by the existing manufacturing means to obtain the selected component (hat frame).

A technical document will define the whole cell for trials as well as the manufacturing process to be run (raw materials, set up phase, methodology, validation procedure to go ahead making full scale parts). The preliminary trials will be established and may consist of the manufacturing of segments of the part. These trials will constitute the set-up of the cell.

WP3. Part Manufacturing Trials and Testing

The cell for trials will be set up and used for manufacturing the demonstrators to validate the proposed concept.

A set of at least four full scale parts will be manufactured, for repetitiveness validation. The tests to validate the part integrity shall be defined (above mentioned technical document) and run.

The parts shall be laid-up, cured and inspected. All the parts shall be manufactured in accordance with the corresponding Technical Document. A Quality report will be provided. The final report of this activity will include measurements and records of the actual manufacturing process, including all the parameters considered relevant to assess the economic cost effectiveness of the expected industrial cell (i.e. lay up speed, labour time, comparison with hand lay-up etc.)

In case of failure, alternative shapes to hat frame profiles shall be studied, proposing alternative geometries, materials, industrial means and trials.

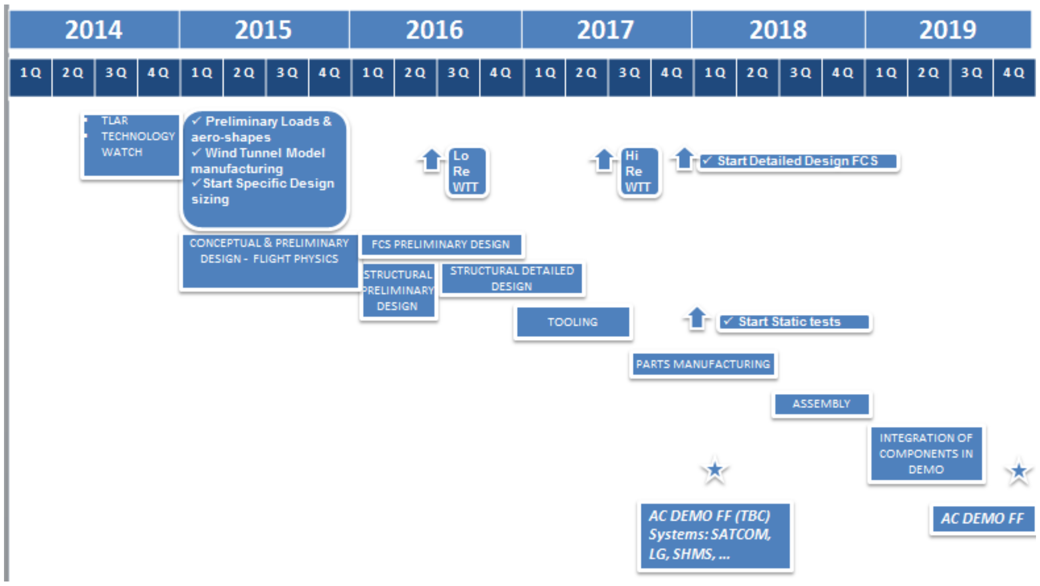
WP4. Industrial Feasibility and Industrial flexible cell definition

The output of the work-package “Part Manufacturing Trials and Testing” will provide the information to define an actual Industrial Cell. Once the feasibility is validated (Technical and Economic) the best industrial solution will be reported. The deliverable of the WP is a document including:

- Main results and advices coming from trials.
- Definition of the Industrial cell. A lay out of the cell shall be provided.
- Parameters achieve cost effectiveness.
- Business Case for manufacturing by automated/assisted system. It will include the investments needed to succeed obtaining automated processes.
- Schedule and procedure for an Industrial Cell implementation.

3. Major deliverables/ Milestones and schedule (estimate)

The deliverables and milestones are in accordance with the general work plan of the Airframe Aircraft FTB2 demonstrator as shown below. The main reference milestone is AC DEMO FF and therefore relevant results and outcomes from this activity have to be provided in advance to this milestone.



In synthesis, the "Automatization of hand lay-up manufacturing process for Carbon Fiber Composite stiffeners" topic will deploy four work-packages.

- **WP1. Definition of Laboratory Cell for trials**
- **WP2. Implementation of Laboratory Cell for trials**
- **WP3. Part Manufacturing Trials and Testing**
- **WP4. Industrial Feasibility and Industrial flexible cell definition**

Next table shows the proposed duration of each Work Package, considering T0: January 2017.

Ref. No.	*Title – Description*	*Duration*
WP.1	**Definition of Laboratory Cell for trials**	T0 + 2M
WP.2	**Implementation of Laboratory Cell for trials**	T0 + 5M
WP.3	**Part Manufacturing Trials and Testing**	T0 + 9M
WP.4	**Industrial Feasibility and Industrial flexible cell definition**	T0 + 12M

The involvement of the "Beneficiary" of this CfP will be the development of the Deliverables in the next table and related with those Work-Packages (WP).

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	**Comparative between current robots and collaborative robots for stiffeners manufacturing** **Design of Laboratory cell using collaborative robots**	R	T0 + 2M
D2	**Report with all the results obtained and conclusions.** **Report with viability study after obtained results.** **Tool to implement the obtained results**	R and P	T0 + 5M
D3	**Part Manufacturing Trials and Testing**	R and P	T0 + 9M
D4	**Industrial Feasibility and Industrial flexible cell definition**	R	T0 + 12M

*Type: R. - Report; P. - Prototype

The applicant will work in close cooperation with the Topic Manager who will provide the adequate information and models. Further innovations and improvements and recommendations from specific studies and analysis proposed by the applicant will be welcomed.

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

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

Demonstrated experience in the following fields:

- Composite Design and Manufacturing
- Composite Materials & Processes: Prepreg – Hi tape – RTM – LRI – Thermoplastic composites – Automated lay-up and inspection
- Robotized and manufacturing automation
- Assisted automation
- Co-operative robots
- Lean manufacturing
- Non Destructive Inspection
- Composite trade off study expertise

XIII. Tests for leakage identification on Aircraft fluid mechanical installations

Type of action (RIA or IA)	IA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	WP B-3.6		
Indicative Funding Topic Value (in k€)	260 k€		
Duration of the action (in Months)	27 months	**Indicative Start Date**[38]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-AIR-02-24	**Tests for leakage identification on Aircraft fluid mechanical installations**
Short description (3 lines)	
The objective of the work is to build dedicated test means (fluid dynamic laboratory) and execute the required tests for confirmation of theoretical simulations, with the final goal of performing eco and reduce cost of fluid dynamic ground tests on aircraft. This call covers the execution of tests on Lab and on demonstrator of IAIR ITD.	

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

1. Background

Clean Sky 2 will deliver break-through technologies for incorporation into the next generations of aircraft from 2025 onwards. By spearheading European aeronautics research culminating in demonstrations of game-changing new vehicle configurations, Clean Sky 2 will enable the aeronautics industry to introduce innovations in timescales that would otherwise be unachievable. In so doing, it will drive environmental improvements, increase transport efficiency, and create jobs and growth for Europe

The framework of this topic is Clean Sky 2 Airframe *Work Package B-3.6: "New Materials and Manufacturing Technologies"*.

This topic deals with on-ground testing technologies applicable to airframes, in particular to the AIR ITD demonstrator which is directly linked to activities performed by the Topic Manager (and/or the associated Core Partner).

Currently most of leakage tests on A/C systems are done using the fluid for which this system is designed for. Some of these system fluids, like hydraulic fluid and fuel are highly polluting and toxic. The objective is to develop innovative methods to make on-ground testing more efficient, ecological and faster in aeronautical industrial environments, reducing costs, time to market and toxic wastes due to standardization on test procedures and test means, and the use of no polluting fluids.

2. Scope of work

On-ground testing of Future Leakage Identification Systems is made up of the following work packages:

- Work package A: Leak detection on aircraft hydraulic system
- Work package B: Leak detection on aircraft fuel system
- Work package C: Leak detection on aircraft fuel tanks
- Work package D: Leak detection on aircraft gas fluid systems
- Work package E: Leaks detection systems: standardization, improvement and innovation
- Work package F: Fluids standardization systems to testability and integration improvement

And, the proposed activities are focused on (for the work packages under CfP responsibility):

- Theoretical-practical development to identify leaks in aircraft gas fluid systems
- Theoretical-practical development to identify leaks in aircraft fuel tanks
- Theoretical-practical development to identify leaks in aircraft fuel systems

Each work package has two different paths, one theoretical path and one practical path. Both paths have certain level of independence but focus on a common objective and therefore a fluent communication between both paths then is required.

- **The theoretical path** (performed by the Topic Manager)**:**
  Main activities are:
  - Collect the state of the art of each work package. The output of this task will be a report with all the references of the reviewed documentation, a summary of the more interesting documents, and a definition of the fay forward for the work package.
  - Model the system and perform all the fluid dynamic simulations in order to understand how the leakages work on the system under study, taking into account the interfaces of the assembled system (e.g. pipes, junctions, adaptors, valves…). Theoretical models will require practical tests confirmation, and therefore, set of laboratory tests will be delivered to the practical path of the work packages. The model must include the influence of the kind of gas to be used, the influence of the pressure of the test, the influence of the volume of the system, the influence of the temperature, the behavior when more than one point of leakage is considered…)

  The final objective of the theoretical path will be the definition of the test to be performed of the system with gas (test pressures, type of gas, time for the test, pass fail criteria…) ensuring no leakages once the system is filled and operated with the normal fluid of the system (hydraulic, fuel, oxygen…).

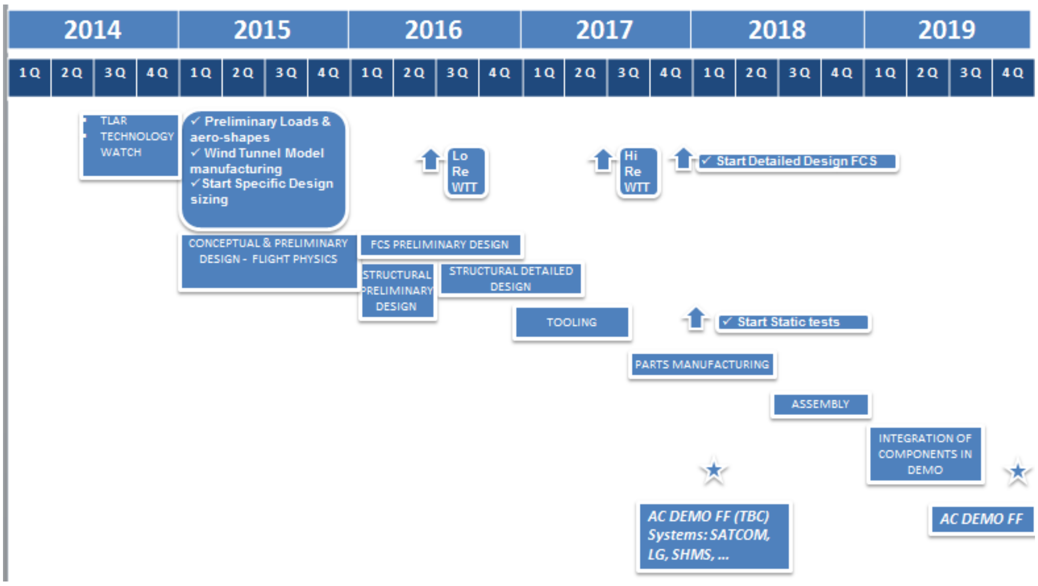
- **The practical path**:
  Main activities are:
  - To prepare and perform all set of laboratory and A/C tests. These set of laboratory test can be defined:
    - by the theoretical path in order to check the models,
    - by the own practical path. These definition are based on comparing the behavior of the junctions and component of the system with the nominal fluid of the system (hydraulic, fuel, oxygen…) and different kind of gases, changing the pressures, durations of the test, different values of torque on the junctions, checking the influence of the temperature, checking the influence of the volume of the system, checking the behavior when a there is more than one point of leakage …
  - To compile, compare and summarize all the test performed, providing conclusion In terms of viability and lessons learned, and providing all the results in a tool to facilitate searches and filters of the tests performed.
  - To prepare a report with all the results of the implementation on demonstrator, providing the final test procedures on A/C with the corresponding pass fail criteria.

  The responsibility of these tasks will depend on the work package (referred to the work packages named at the beginning of this section):
  - The partner will be responsible for the tasks on the work packages B, C and D (fuel system, fuel tanks and pneumatic systems), with the supervision of Topic Manager.
  - Topic Manager will be responsible for the tasks on work packages A and E. Work package F is also under Topic Manager Responsibility.

All tasks will be applied on AIR ITD related demonstrator.

3. Major deliverables/ Milestones and schedule (estimate)

The deliverables and milestones are in accordance with the general work plan of the Airframe Aircraft FTB2 demonstrator as shown above. The main reference milestone is AC DEMO FF and therefore relevant results and outcomes from this activity have to be provided in advance to this milestone.



"On-ground testing of Future Leakage Identification System" activities asked in this topic can be grouped in 3 Work Packages (WP):

- **WP 1. Theoretical-practical development to identify leaks in aircraft gas fluid systems**
- **WP 2. Theoretical-practical development to identify leaks in aircraft fuel tanks**
- **WP 3. Theoretical-practical development to identify leaks in aircraft fuel systems**

Next table shows the duration of each Work Package, considering T0: January 2017.

Ref. No.	***Title – Description***	***Duration***
WP.1	**Theoretical-practical development to identify leaks in aircraft gas fluid systems**	T0 + 24M
WP.2	**Theoretical-practical development to identify leaks in aircraft fuel tanks**	T0 + 27M
WP.3	**Theoretical-practical development to identify leaks in aircraft fuel systems**	T0 + 18M

The involvement of the "Beneficiary" of this CfP will be the development of the Deliverables in the next table, in relation with the Work Packages (WP) named before.

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	**Theoretical-practical development to identify leaks in aircraft gas fluid systems**		
	Laboratory and aircraft testing	R	T0 + 17M
	Summary of results: theoretical and functional results comparison	R and P	T0 + 21M
	Results implementation in aircraft	R	T0 + 24M
D2	**Theoretical-practical development to identify leaks in aircraft fuel tanks**		
	Laboratory and aircraft testing	R	T0 + 17M
	Summary of results: theoretical and functional results comparison	R and P	T0 + 21M
	Results implementation in aircraft	R	T0 + 27M
D3	**Theoretical-practical development to identify leaks in aircraft fuel systems**		
	Laboratory and aircraft testing	R	T0+11M
	Summary of results: theoretical and functional results comparison	R and P	T0 + 15M
	Results implementation in aircraft	R	T0 + 18M

R. - Report; P. - Prototype

The applicant will work in close cooperation with the Topic Manager who will provide the adequate information and models. Further innovations and improvements and recommendations from specific studies and analysis proposed by the applicant will be welcomed.

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

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

Requested skill are:

- Experience in aircraft systems installation (pneumatic, and fuel installations, fuel tanks)
- Experience on tightening and leakage testing on aircraft systems installation with pneumatic test benches, and also testing activities using the fluid of the aircraft system (gases and fuel/shellsol).
- Experience on defining and operating the set of testing tools required for the laboratory and testing activities
- Experience on defining the set of laboratory and aircraft test in line with theoretical simulations
- Experience on reporting testing activities, with capacity of comparing test results with theoretical cases and providing conclusions for the results.
- High level of communication skills required to ensure the continuous interaction between the team in charge of theoretical simulations, providing appropriate feedback.

XIV. Development and demonstration of materials and manufacturing process for high structural damping composite beams for civil rotor and airframe applications

Type of action (RIA or IA)	IA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	WP B-4.2		
Indicative Funding Topic Value (in k€)	500 k€		
Duration of the action (in Months)	54 months	**Indicative Start Date**[39]	Q1 2017

Identification	Title
JTI-CS2-2016-CFP03-AIR-02-24	**Development and demonstration of materials and manufacturing process for high structural damping composite beams for civil rotor and airframe applications**
Short description (3 lines)	
The research shall provide a manufacturing process capable of producing flight cleared fibre reinforced high strength plastic components characterized by high structural damping through a change of resin system and/or laminating high damping layers on a typical composite structure.	

[39] 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.

2. Scope of work

The aim of this project is to eliminate, or significantly reduce the requirement for discrete lag dampers in the tilt-rotor head configuration by incorporating lead-lag damping capability (damping ratio of between 4-5%) into the rotor head structure via integrated structural elements.

The focus of this project is the development and substantiation of flight cleared fibre reinforced high strength plastic components characterized by high structural damping to be integrated into a large scale flightworthy civil tiltrotor demonstrator.

The components are envisaged as “arms” of the rotor head (in the plane of the rotor, one arm per blade) that restrain the blade and associated bearing against centrifugal force while allowing lead-lag motions and providing the required damping of those motions. The arms would also react loads from thrust and vertical motions of the blades, as well as loads generated by motions in the bearings that attach the blades.

The internal details of the arms are to be designed based on the characteristics of the technology proposed by the partner company. The proposed configuration is to be validated via structural element testing in advance of the detail design.

The partner company will be responsible for the detail design, manufacture, and flight clearance qualification of the arms in parallel with the overall rotor design.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T0	Project Management	T0-T0+54
T1	Identification of the most suitable structural elements	T0-T0+12
T2	Manufacture and free-free testing of structural elements, including (if applicable) the sensitivity of the complex eigenvalues and eigenvectors to the amplitude of motion and the frequency	T0+12-T0+18
T3	Derivation of the structural damping matrix of the element	T0+18-T0+30
T4	Manufacture and free-free testing of a preliminary flight specimen and generation of the structural damping matrix	T0+24-T0+36
T5	Upgrading of the structural element according to the evolution of the overall rotor design	T0+36-T0+42

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T6	Manufacture and flight clearance (dynamic and fatigue) testing of the upgraded element (including sensitivity to extreme temperature range -40°C/+55°C), and delivery of manufacturing technology	T0+42-T0+54

Further details related to specific activities are given below:

Task T0:
Accounts for ongoing project management of the programme.

Task T1:
The design parameters to be considered during Task 1 are as follows:

- Maximum motion range:
  ±10° Flapping
- Minimum weight to fulfil functional requirements
- Operating temperature range of -40°C to +55°C
- Damping ratio: 4-5%
- In terms of strain, two material allowables have been defined:
  Endurance(10^8 cycles) with static and dynamic strains of 6000 +/- 6000 με
  Limit strain > 15000 με
  The strain allowables are defined to be consistent with the strains reacted by the primary structure, there is no requirement for additional stiffness contribution.

Task T2:
At least two (2) representative structural element specimens will be manufactured by the Partner to be tested at a location agreed between the Partner and the Topic Manager.

Task T3:
The Topic Manager will ask to apply a specific testing procedure in order to have from the Partner the proper input data to be used in the Topic Manager developed code. The code will be used by the Topic Manager. Based on the Partner's competencies and proposed solution, it will be the opportunity to jointly define an alternative approach to obtain the info for the definition of the structural damping matrix.

Task T4:
Manufacture by the Partner of a preliminary flight specimen with integrated structural element for the tiltrotor rotor system application. Geometry of the structure surrounding the structural element will be provided by the Topic Manager.

Task T5:
Tuning of the structural element according to the evolution of the overall rotor system characteristics

Task T6:
Manufacture and dynamic characterisation/fatigue test of flight representative hardware.__Manufacture of hardware for NextGenCTR Demonstrator.

General Remarks:
Integration into the overall rotor design will be an ongoing activity to ensure acceptable dynamic performance of the rotor system and that geometric and kinematic clearance between rotor system components are maintained.
Development of the high damping structural element will be conducted in close cooperation with the Topic Manager.
It is expected, that by T0+30 (CDR), at least TRL 4 is achieved for each system/technology proposed. If this is not achieved on time, Partner has to initiate a mitigation plan how to reach the target of TRL 6 at the end of demonstration.
All correspondence and technical proposals shall be written in English. Where the originals of any documents submitted are in a language other than English, a translation shall be provided.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D1	Delivery of a Report/Presentation on the most suitable techniques and structural elements	Report/ Presentation	T0+11
D2	Delivery of the Test Proposal detailed features	Report	T0+15
D3	Delivery of the free-free Test Report	Report + Presentation	T0+20
D4	Structural Damping Matrix Identification	Report	T0+32
D5	Preliminary flight specimen Structural Damping Matrix Identification	Report	T0+40
D6	Final Flight Specimen Structural Damping Matrix Identification and fatigue flight clearance achieved, Technological Process and sensitivity to temperature, amplitude of motion and frequency	HDW + Report	T0+54

Milestones			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	PDR	Design Review	T0+12
M2	Free-Free Test Proposal	Test Proposal Availability	T0+15
M3	CDR (Achieved TRL-4)	Design Review	T0+30
M4	Structural Damping Matrix Identification Report	Report Availability	T0+34
M5	Preliminary flight specimen Structural Damping Matrix Identification Report	Report Availability	T0+40
M6	Flight cleared hardware (Achieved TRL-6)	Hardware Availability	T0+54

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

(M) – Mandatory; (A) – Appreciated

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

- Material data which are required to achieve a "Permit to Fly".
- Using material, processes, tools, calculation tools etc. which are commonly accepted in the aeronautic industry and by certification authorities.
- Harmonization (through Topic Manager) of calculation processes/tools.
- Interaction with the Topic Manager at each stage of development.
- Access to production and test facilities.
- The Partner has to perform the updates of documentation in case of insufficient documentation for authorities.

Special Skills

- ✓ Structural damping features and sensitivity to all possible influencing parameters
- ✓ Dynamic Experimental assessment detailed knowledge
- ✓ Theoretical vs experimental correlation capability
- ✓ Competence in management of complex projects of research and manufacturing technologies.
- ✓ Experience in design and manufacturing of structures in non-conventional and conventional composite materials (thermoset and thermoplastic plus high temperature systems).

- ✓ Design, analysis and configuration management tools of the aeronautical industry (i.e. CATIA v5 release 21, Abaqus, VPM)
- ✓ Experience with TRL Reviews or equivalent technology readiness assessment techniques in research and manufacturing projects for aeronautical or automotive industry
- ✓ It is desirable to have proven experience in collaborating with reference aeronautical companies with industrial air vehicle developments with “in–flight” components experience.
- ✓ Capacity to support documentation and means of compliance to achieve experimental prototype “Permit to Fly” with Airworthiness Authorities (i.e. EASA, FAA and any others which may apply).
- ✓ Capacity to specify material and structural tests along the design and manufacturing phases of aeronautical components, including: material screening, panel type tests and instrumentation.
- ✓ Capacity to perform structural and functional tests of aeronautical components: test preparation and analysis of results
- ✓ Capacity to repair “in-shop” components due to manufacturing deviations.
- ✓ Capacity of performing Life Cycle Analysis (LCA) and Life Cycle Cost Analysis (LCCA) of materials and structures.
- ✓ Design Organization Approval (DOA) is desirable
- ✓ Product Organization Approvals (POA) is desirable
- ✓ Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004)
- ✓ Qualification as Material and Ground Testing Laboratory of reference aeronautical companies (i.e. ISO 17025 and Nadcap).
- ✓ Technologies for composite manufacturing with Out of Autoclave (OoA) processes: e.g. Resin Transfer Molding (RTM), Infusion, Same Qualified RTM Thermoforming, Roll-forming
- ✓ Mechanical processes, in both composite material and metallic. Hybrid joints (Composite Fibre Reinforced Plastic/Polymer, (CFRP) + Metal).
- ✓ Manual composite manufacturing: hand lay-up
- ✓ Tooling design and manufacturing for composite components.
- ✓ Advanced Non Destructive Inspection (NDI) and components inspection to support new processes in the frame of an experimental Permit to Fly objective.

Material and Processes

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

Materials used in the design solution must be compliant with the requirements of REACH.

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

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

The TRL review will be held in correspondence with the design reviews (PDR, CDR) to ensure that 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 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.
The back-up plan, which shall secure the meeting of the project goals, shall also be agreed between the Topic manager and the Partner within twelve (12) months after start of the activities.
Furthermore the management and planning activities in this Call shall support the safe inclusion of the partner technology into the complete flying NextGenCTR Demonstrator.

XV. Development of innovative automated fiber placement machine for composite fuselage manufacturing with high performance hybrid materials

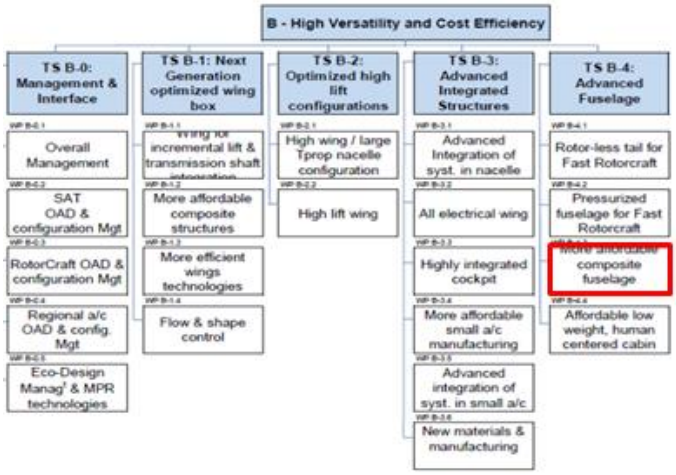
Type of action (RIA or IA)	IA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	WP B-4.3		
Indicative Funding Topic Value (in k€)	2700 k€		
Duration of the action (in Months)	30 months	**Indicative Start Date**[40]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-AIR-02-25	**Development of innovative automated fiber placement machine for composite fuselage manufacturing with high performance hybrid materials**
Short description (3 lines)	
Activities described in the present Topic shall contribute to develop and validate an advanced process of hybrid materials automated lay-up for manufacturing of regional aircraft composite fuselage which allows a significant reduction of the overall production costs and manufacturing flow. After a developmental phase to be performed at Partner site, the innovative process and related machine shall be validated and costs assessed through the execution of dedicated lay-up tests and fabrication of fuselage demonstrators at Topic Manager plant.	

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

1. Background

Activities to be performed according to the present topic description are included in a wider context of work in the framework of the Airframe ITD of Clean Sky 2. In particular, the Work Package B-4.3 “More Affordable Composite Fuselage” is incorporated within the Technology Stream B-4 and represents the field where activities requested to the Applicant shall be performed. The relevant ITD Work Breakdown Structure is shown below putting in evidence the WP B-4.3:



More in detail, the activities of the WP B-4.3 will pursue the development of the technologies and methodologies already studied in Clean Sky - GRA ITD and in other EU projects addressing the feasibility of a composite fuselage for a Regional Turbo Prop aircraft. The objective is to drive the development of that technologies and methodologies to innovative solutions which take into consideration driver factors indispensable for the industrialization: increased structural integration, reduced total costs and structural weight, enhanced multifunctional materials, 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 an advanced process of hybrid materials automated lay-up for regional aircraft composite fuselage manufacturing which allows a significant reduction of the overall production costs and flow. Moreover, the scope is also to further develop an acoustic damping material to make it suitable for automated lamination and integration in the multifunctional fuselage component.-

Main requirements of the innovative automated machine are:

1) Head configuration in order to enable an efficient lamination of different materials and the ultrasonic cutting to shape of the laminate;
2) Materials to be laid: prepreg UD slit tape, viscoelastic layer.
3) A rotating positioner, longitudinally movable, for a more flexible process.
4) An IR heater system to enhance material adhesion and quality laydown.
5) Capability to lay-down the following fuselage configurations :
   - one piece barrel, up to 3.5 m diameter, 5 m length.
   - fuselage panels, same diameter and length (3 or 4 panels).
6) Compact layout (available area for machine and layup tool = 10m x 5.5m).
7) Layup performance compliant with the requirements of the applicable equipment qualification.
8) Minimum run productivity for slit tape = 50 Lbs/h.
9) Minimum floor to floor productivity for slit tape = 30 Lbs/h.

To achieve the proposed objectives, the main activities to be performed are:

- trade-off study in terms of cost and production rate among a set of pre-identified material sizes and machine configurations for the fuselage components of interest: skin and stringer flat charges;
- development of viscoelastic material used for Clean Sky in order to make it suitable for automated lamination, compatible with the selected prepreg material and preliminary test plan to assess potential impact on main prepreg allowables;
- CS viscoelastic material definition as regards to backing paper, width and carrier (if needed) and slitting for automated lay-up;
- machine heads development, testing and integration in the equipment;
- set-up tests to verify machine performance and conformance to the lay-up requirements in terms of end placement (+/-2.5 mm) and lay-up quality (maximum gap allowed during acceptance tests is 0.75 mm).
- pre-acceptance tests at the supplier site including functional and manufacturing trials (n°2 flat skins and n°2 curve ones, 1.5m x 1.5m)
- machine shipment to the Topic Manager plant and machine assembly;
- acceptance/qualification tests and repeatability tests (n°2 flat panels and n°3 curve panels, 1.5m x 1.5m);
- structural composite material mechanical characterization (n°10 flat panels, 1m x 1m, bridge plan for main allowables verification of automated lay-up and hybrid material);
- automated lay-up of the first verification article to be evaluated with destructive analysis;

- automated lay-up of n°2 final demonstrators manufactured with the identified and set-up process;
- support to the automated lay-up for fabrication of structural panels (dimensions up to 1.7m x 5.0 m).

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 + 2
2	Viscoelastic Material Development and Testing	T0 + 10
3	Automated Fiber Placement Machine (AFPM) Design/Development/Construction	T0 + 12
4	Equipment Pre-Acceptance	T0 + 12
5	Material Mechanical Characterization	T0 + 22
6	Equipment Acceptance and Qualification	T0 + 18
7	Fuselage Demonstrators Manufacturing	T0 + 30

The following inputs will be provided by the topic manager:

- final layout for machine installation;
- structure prepreg material to be used for the project (already identified by Topic Manager);
- general properties of viscoelastic layers;
- lay-up quality requirements;
- pre-acceptance/acceptance/qualification minimum requirements;
- manufacturing and structural trials, PPV and final demonstrator design;
- test matrix for prepreg and viscoelastic layer mechanical characterization and relevant standard specifications.

For the project execution, the Topic Manager will provide prepreg material and lay-up tool for first and final demonstrators.

Task 1 - Trade-off and Machine Technical Specification

Actually advanced Automated Fiber Placement (AFP) technologies development for composite parts is mainly focused to reduce manufacturing costs through:

- flexible and high performance equipment able to fabricate very complex components on both male and female tools;
- prepreg diversification: not only prepreg slit tape but also hybrid materials (as viscoelastic layers);
- use of new materials for AFP process as dry fiber and/or thermoplastics;
- multi-head solutions which allow a fast material change reducing down-time.

The following fuselage configurations shall be investigated as regards to the lay-up process:

1. one piece barrel, 3.5 m diameter, 5 m length.
2. fuselage panels, same diameter and length (3 or 4 panels).

The final fuselage configuration will be communicated by Topic Manager during the Kick-Off Meeting.

The following machine configurations shall be investigated:

1. AFPM based on geometry gantry
2. AFPM based on anthropomorphic robot

The above innovative configurations shall be compared in terms of cost and production rate, which will lead to the selection of the best solution.
AFPM shall satisfy the requirements listed above at the beginning of section 2.

A complete technical specification shall be prepared as answer to the above request. It shall include at least:

- equipment configuration and layout;
- productivity data;
- process parameters;
- machine acceptance test proposal.

Task 2 - Viscoelastic Material Development and Testing
General properties of viscoelastic layers, already used in Clean Sky program, will be provided by Topic Manager as well as prepreg material to be used for the project.
Applicant shall define the different changes to the viscoelastic material format to make it suitable for automated lay-up (width, carrier, backing paper, spool dimensions, etc.). Then functional manufacturing trials with automated lay-up shall be performed to select and validate the final material configuration and develop the automated lay-up process.
A testing campaign shall be performed by the applicant to assess the developed viscoelastic layer performance, in terms of handling features, compatibility with the selected prepreg and characteristics of the resulting cured layer.

Task 3 – AFPM Design/Development/Construction
Automated lay-up of hybrid materials or materials different from composite tapes, as multifunctional composite for acoustic improvements, thermal protection, EME or lightning features, is now limited by the absence of adequate commercial sizes to be used on AFPM and there is also a technical limitation in the use of materials that are stretchable when tensioned during AFP lay-up to the detriment of quality laydown.
However the interest of automated lay-up for these materials is growing up since there is clearly a potential saving in the application of these materials during AFP process instead of a hand lay-up during fabrication or assembly phase.
Machine design and construction and development of the lay-up heads shall be conducted in parallel with viscoelastic materials development.
Again AFPM shall satisfy the requirements listed above and in task 1.

Once machine integration will be completed and all materials prepared in a size usable on AFPM, a preliminary test phase shall be conducted in order to verify:

1. equipment set-up and/or possible hardware/software modifications;
2. key process parameters;
3. lay-down quality and end placement accuracy.

Task 4 – Equipment Pre-Acceptance

A pre-acceptance phase shall be conducted before equipment shipping to the Topic Manager in order to verify technology readiness and conformance to the requested performance level.

Pre-acceptance minimum requirements and relevant lay-up quality criteria will be communicated by Topic Manager.

A dedicated test book shall be prepared including functional flat and contoured test panels with all materials identified and tested according to Task 2. Additionally n°2 flat skins and n°2 curve ones, 1.5m x 1.5m, shall be fabricated and cut as first manufacturing trials. Also one flat charge for stringer will be laminated and cut.

Test article configuration will be communicated by Topic Manager.

The outputs of this task shall be:

- process/equipment set-up for the different materials;
- definition even if preliminary of the main Key process parameters;
- estimated level of laydown quality and end placement accuracy for all materials.

After the conclusion of this task, the machine shall be disassembled and shipped to Topic Manager plant.

Task 5 – Material Mechanical Characterization

During equipment acceptance/qualification tests the structural composite material qualification, i.e. a bridge plan for main allowables verification of automated prepreg and hybrid material lay-up shall be conducted. The data produced after testing shall be compared to those obtained from original prepreg qualification.

The applicant shall be responsible for panels automated lay-up (n°10 flat panels, 1m x 1m, plus a panel for NDI standard) at Topic Manager site, coupon trimming/drilling/assembly and testing and data reporting.

Topic Manager will have instead the responsibility of flat panels bagging, cure, debagging and NDI inspection.

A test plan to assess potential impact on main prepreg allowables will be prepared by the Topic Manager. Test Plan will include the required number and typology of items to be fabricated and mechanically tested to evaluate material properties and knock down factors. The test matrix for prepreg and viscoelastic layer mechanical characterization and relevant standard specifications will be provided by Topic Manager.

Task 6 – Equipment Acceptance/Qualification

An acceptance/qualification task, similar but more in depth than pre-acceptance, shall be performed after final installation in the Topic Manager facility.

Acceptance/qualification minimum requirements and relevant lay-up quality criteria will be communicated by Topic Manager.

Differently from pre-acceptance, acceptance/qualification phase shall involve the overall equipment characterization through:

1. calibration of the main gauges, sensors and recording instruments for process control;
2. operational tests including calibration of: creel temperature and RH, tensioning system, head cooling and compaction force;
3. IR heater set-up and logic definition;
4. flat and contoured test panels with all materials;
5. machine axis certification.

In addition, a repeatability test, including n°2 flat panels n°3 curve ones, 1.5m x 1.5m, shall be conducted after calibrations and functionality tests. Also flat charges for stringers to be integrated on the flat and curve panels shall be laminated and cut.

The outputs of this task shall be:

- final process/equipment set-up for the different materials;
- complete definition of the main Key process parameters;
- compliance with the requested level of laydown quality and end placement accuracy for all materials.

Task 7 – Fuselage Demonstrators Manufacturing

N°3 representative demonstrators shall be laminated jointly by Topic Manager and partner (skin and stringer flat charges) to validate process, manufacturing costs and weight estimation: a first 5 m long fuselage barrel as preliminary verification and second and third fuselage barrel of same dimensions as final demonstrator for Clean Sky 2 project.

Barrel skin thickness will be approximately between 8 and 24 plies while stringers will have gages between 8 and 14 plies. Both skin and stringer will have full plies and doublers as well.

The composite fuselage barrel will include acoustic damping capability through automated lay-up of the identified viscoelastic layers.

Final design configuration of both first and final demonstrators will be communicated by Topic Manager.

A first set of PPM (Pre-Production Manufacturing) sub scale fuselage portions will be laminated before demonstrators only if fabrication process will not be satisfactory completed after manufacturing trials performed during equipment pre-acceptance and acceptance.

The first manufactured fuselage barrel shall be destructively characterized in order to verify internal quality (defects not visible to NDI), define structural properties and freeze process parameters.

Final demonstrators and manufacturing report (containing lay-up process details) shall be provided at the end of the Task as well as final weight assessment and recurring cost evaluation for industrial production (limited to the automated lay-up) with indication of number and type of equipment needed to achieve the target rate.

All experimental data and correlated results analysis shall be included in the Test Reports.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D1.1	Machine Configurations Trade-off Analysis	Report	T0 + 2
D1.2	Machine Technical Specification	Report	T0 + 2
D2.1	Hybrid materials development/testing and selection of materials to be used on AFPM	Report	T0 + 10
D2.2	Material preparation and slitting	Hardware	T0 + 10

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D3.1	Equipment Design	Drawing	T0 + 6
D3.2	Equipment Construction	Hardware	T0 + 10
D3.3	Tools Design and Construction	Hardware	T0 + 10
D3.4	Part Program Preparation	Part Program	T0 + 10
D4.1	Pre-Acceptance Test Book Preparation	Report	T0 + 10
D4.2	Pre-Acceptance Tests and Report Preparation	Hardware + Report	T0 + 12
D5.1	Material Mechanical Characterization Tests and Report	Hardware + Report	T0 + 22
D6.1	Machine Installation at Topic Manager site	Hardware	T0 + 14
D6.2	Acceptance Test Book/Qualification Plan Preparation	Report	T0 + 15
D6.3	Part Program Preparation	PP	T0 + 15
D6.4	Acceptance/Qualification Tests and Report Preparation	Report	T0 + 18
D7.1	Part Program Preparation	PP	T0 + 20
D7.2	Tools Design and Construction	Hardware	T0 + 18
D7.3	Representative Article Automated Lay-up (PPV)	Hardware	T0 + 21
D7.4	Final Representative Fuselage Demonstrators Automated Lay-up	Hardware	T0 + 27
D7.5	Final Manufacturing and Cost/Weight Assessment Report	Report	T0 + 30

	Milestones (when appropriate)		
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Viscoelastic Material Definition – D.2.1	Report	T0 + 10
M2	Equipment Construction – D.3.2	Hardware	T0 + 10
M3	Pre-Acceptance Tests and Report Preparation – D.4.2	Hardware + Report	T0 + 12
M4	Machine Installation at Topic Manager site	Hardware	T0 + 14
M5	Material Mechanical Characterization Tests and Report – D.5.1	Hardware + Report	T0 + 22
M6	Acceptance/Qualification Tests and Report Preparation – D.6.4	Report	T0 + 18
M7	Final Representative Fuselage Demonstrator Automated Lay-up – D.7.4	Hardware	T0 + 27
M8	Final Manufacturing and Cost/Weight Assessment Report – D.7.5	Report	T0 + 30

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

(M) – Mandatory; (A) – Appreciated

- ✓ proven competence in design and stress analysis of aeronautical composite structural components by a documented experience in participating in actual aeronautical programme design phase.
- ✓ proven experience in automated lay-up of aeronautical composite substructures for actual aeronautical programmes. This competence shall include a strong knowledge of materials and processes, quality, tooling, part programs for CN machines.
- ✓ proven experience in experimental testing at coupon levels. Evidence of laboratories qualification shall be provided.
- ✓ proven experience in automated fiber placement machine (AFPM) design and manufacturing for aeronautical programmes.
- ✓ proven experience in cost estimation at industrial level for composite component automated lamination.
- ✓ proven experience in composite and/or hybrid materials fabrication and slitting.

XVI. Development, fabrication, verification and delivery of innovative and flexible system for automated drilling and fastener insertion on fuselage barrel

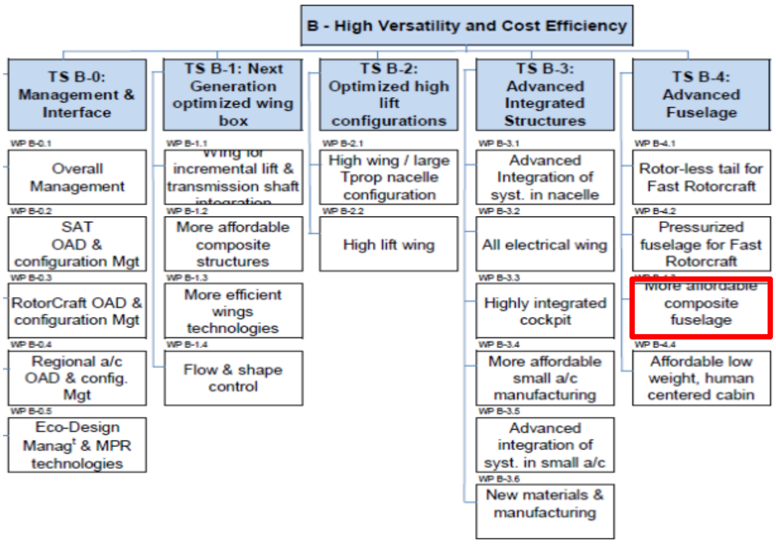
Type of action (RIA or IA)	IA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	WP B-4.3		
Indicative Funding Topic Value (in k€)	900 k€		
Duration of the action (in Months)	30 months	**Indicative Start Date**[41]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-AIR-02-26	**Development, fabrication, verification and delivery of innovative and flexible system for automated drilling and fastener insertion on fuselage barrel**
Short description (3 lines)	
The aim of the present topic is to develop and validate a Flexible system for automated drill of regional aircraft composite fuselage which allows a significant reduction of the overall production costs and flow.	

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

1. **Background**

Activities to be performed according to the present topic description are included in a wider context of work in the framework of the Airframe ITD of Clean Sky 2. In particular, the Work Package B-4.3 "More Affordable Composite Fuselage" is incorporated within the Technology Stream B-4 and represents the field where activities requested to the Applicant shall be performed. The relevant ITD Work Breakdown Structure is shown below putting in evidence the WP B-4.3:



More in detail, the activities of the WP B-4.3 will pursue the development of the technologies and methodologies already studied in Clean Sky - GRA ITD and in other EU projects addressing the feasibility of a composite fuselage for a Regional Turbo Prop aircraft. The objective is to drive the development of that technologies and methodologies to innovative solutions which take into consideration driver factors indispensable for the industrialization: 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, fabrication, verification and delivery of flexible system for automated drill of regional aircraft composite fuselage and fastener insertion which allows a significant reduction of the overall production costs and flow.

The machine 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 (just fastener insertion) head, capable to drill and countersink in one pass full size holes both in composite and in metal, equipped with sealing tool and hole/countersink measurement probe,
- Head moving line, made by rail or dolly or similar, to be positioned on the fuselage in order to allow the drilling head to move to all hole locations, both in x and y axis, 360 degrees.
- Positioning, normalizing and alignment system, to allow the machine to align on DA holes, to self -

adjust normal to drilling surface and to set the drilling stroke taking into account also the countersink depth. Machine has to be equipped with servo axis control and portable CNC.

The machine 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 barrel;
- machine design, comprehensive of the three main components: drilling and fastening (sealing and insertion) head, head moving equipment (both x and y axis, 360° rotating around the fuselage) and positioning and alignment system;
- Test Plan definition to assess the main mechanical and technological characteristics of the drilling and fastening 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 supplier site including functional and manufacturing trials (on flat and curved panels);
- machine shipment to the Topic Manager plant and machine assembly;
- acceptance tests and repeatability tests;
- CN integration;
- 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 + 2
2	Equipment design	T0 + 6
3	Test Plan of the three main components and their integration	T0 + 8
4	Equipment development and construction	T0 + 20
5	Pre-acceptance tests	T0 + 22
6	Equipment Acceptance	T0 + 24
7	Fuselage Demonstrators Drilling and Fastening	T0 + 30

Task 1 - Trade-off Study and Machine 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:

3. Automated drilling of composite structure, with particular attention to quality requirements, innovation and high automation level;
4. Automated fastener insertion, with particular attention to the capability to choose the right fastener in terms of length;
5. 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 capable to move on an aircraft fuselage, 360 degrees.
A minimum of two different configurations for each process shall be discussed. These configurations shall be compared in terms of cost, production rate and level of integration and a final best solution shall be selected.

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;
- machine acceptance test proposal.

Task 2 – Equipment design
Equipment shall be designed to fully satisfy requirements described in this document.
Equipment shall be an integrated system of the three main components: drilling and fastening (sealing and insertion) head, head moving equipment (both x and y axis, 360° rotating around the fuselage) 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 drill 7/16” composite and Titanium holes
- Holes Automatically Probed for Diameter, Countersink and Grip Measurements
- Application of automated adjustable force with a pneumatic pressure foot
- Capability to understand the materials into stack-up and automatically change parameters
- System of thrust force records
- System of fastener sealing for wet installation
- System of coolant for hole drilling
- Peck cycle testing for improved metal chip clearance
- Portable CNC
- Runs on flexible rails, or similar
- System of Rails, or similar, attached to the fuselage
- Functionality of a 5 axis machine
- Lower cost than large dedicated machines
- Normality sensing, laser edge finder, panel distance sensing, X e Y moving

- Capability of Rotating around all the fuselage

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, listing and describing all the tests that have to be conducted to develop the process.

Test Plan shall be elaborated with a DOA approach, in order to test all the configurations and to allow choosing the best one.

It 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 choosing the best solution that can lead to the full development of the equipment.

Task 4 - Equipment development and construction

Equipment shall satisfy all design requirements and shall be developed, based on the results of the test listed into Test Plan (Task 3).

Task 5 – Pre-acceptance tests

A pre-acceptance phase shall be conducted before equipment shipping to the Topic Manager 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 Topic Manager

A dedicated test book shall be prepared including functional and manufacturing trials (on flat and curved panels)

Outputs of this task shall be:

- process/equipment set-up for all the different combination of stack-up;
- definition even if preliminary of the main Key process parameters;
- estimated level of quality and positioning precision.

After the conclusion of this task, the machine shall be disassembled and shipped to Topic Manager plant.

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.

Acceptance minimum requirements and relevant quality criteria will be communicated by 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;
- compliance with the requested level of quality and positioning.

Task 7 - Fuselage Demonstrators Drilling and Fastening

Equipment shall be tested on final demonstrator of Clean Sky 2 project.

3. Major deliverables/ Milestones and schedule (estimate)

	Deliverables		
Ref. No.	***Title – Description***	***Type***	***Due Date***
D1.1	Machine Configurations Trade-off Analysis	Report	T0 + 2
D1.2	Machine Technical Specification	Report	T0 + 2
D2.1	Equipment Design: description report	Report	T0 + 6
D2.2	Equipment Design: drawing	Drawing	T0 + 6
D3.1	Test Plan: drilling tool	Report/DOA	T0 + 8
D3.2	Test Plan: fastener insertion and sealing tool	Report/DOA	T0 + 8
D3.3	Test Plan: moving and alignment system	Report/DOA	T0 + 8
D4.1	Test Report	Report	T0 + 18
D4.2	Equipment Construction	Hardware	T0 + 20
D4.3	Part Program	PP	T0 + 20
D4.4	CN procedure and routines description	Report	T0 + 20
D5.1	Pre-Acceptance Test Book	Report	T0 + 22
D5.2	Pre-Acceptance Tests and Report	Hardware + Report	T0 + 22
D6.1	Acceptance Test Book	Report	T0 + 24
D6.2	Part Program	Part Program	T0 + 24
D6.3	Acceptance Tests and Report	Report	T0 + 24
D7.1	Final Manufacturing and Cost/Weight Assessment Report	Report	T0 + 30

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Equipment Design: description report	Report	T0 + 6
M2	Equipment Construction	Hardware	T0 + 20
M3	Final Manufacturing and Cost/Weight Assessment Report	Report	T0 + 30

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

- ✓ Proven competence in design and construction of equipment for aeronautical composite components assembly, by a documented experience in participating in actual aeronautical programme
- ✓ Proven experience in assembly of aeronautical composite full scale substructures for actual aeronautical programmes. This competence shall include a strong knowledge of processes, quality, tooling, part programs for CNC machines.
- ✓ Proven experience in experimental testing from coupon levels up to aeronautical full scale substructures. Evidence of qualification shall be provided
- ✓ Proven experience in cost estimation at industrial level for aeronautical full scale composite structures.

XVII. Development of equipment for composite recycling process of uncured material

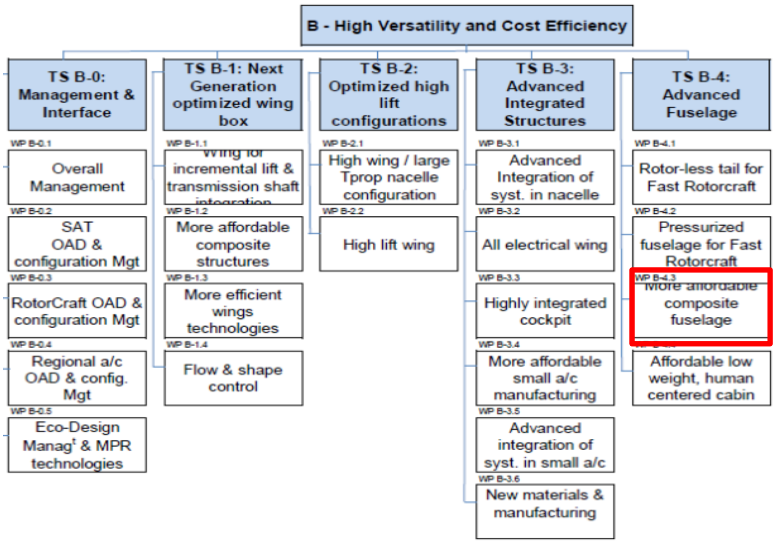
Type of action (RIA or IA)	RIA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	WP B-4.3		
Indicative Funding Topic Value (in k€)	500 k€		
Duration of the action (in Months)	36 months	**Indicative Start Date**[42]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-AIR-02-27	**Development of equipment for composite recycling process of uncured material**
Short description (3 lines)	
The objective of the call is to develop a key process for recovery and recycling of CFRP uncured scraps, coming from lamination activity. In particular activities to be performed are: design, feasibility study, development and validation of equipment that is able to cut and distribute the CFRP wet scraps in such a way to generate a new pre-impregnated material.	

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

1. Background

Activities to be performed according to the present Topic description are included in a wider context of work in the framework of the Airframe ITD of Clean Sky 2. In particular, Work Package B-4.3 “More Affordable Composite Fuselage” is incorporated within the Technology Stream B-4 and represents the field where activities requested to the Applicant shall be performed. The relevant ITD Work Breakdown Structure is shown below putting in evidence WP B-4.3:



More in detail, the activities of WP B-4.3 will pursue the development of the technologies and methodologies already studied in Clean Sky - GRA ITD and in other EU projects addressing the feasibility of a composite fuselage for a Regional Turbo Prop aircraft. The objective is to drive the development of that technologies and methodologies to innovative solutions which take into consideration driver factors indispensable for the industrialization: increased structural integration, reduced total costs and structural weight, enhanced multifunctional materials, reduced environmental impact and extended duration of A/C life.

2. Scope of work

During lamination activities (both manual and automated) with CF pre-impregnated materials, a lot of scraps are generated due to different ply orientation and specific boundaries required. These scraps are also very difficult and costly to be disposed due to national and European regulations/laws.

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

As a matter of fact the Topic Manager Company that is issuing this call for proposal has already developed an uncured CFRP scraps recycling process concept aimed to re-use, rather than waste, material scraped during lamination. This process is therefore background proprietary information owned by the TM Company and

covered by patent in Italy, Europe and USA.
The scope of the present call is, starting from and within the limits of the patent, to define in details the process parameters of automated material cutting and distributing, and to develop, realize and validate the relevant equipment.
Property of background information and results of the work performed within this Call for Proposal will be handled according to the rules of Clean Sky 2.
In details, the uncured CFRP scraps coming in different shape and dimension from pre-impregnated excess material cutting during unidirectional plies lamination, have to be cut using a suitable device in small elements, after backing paper removal (if any). These elements, in the following “CFRP chips”, have to be of defined dimensions: 8 mm transverse to fibre direction x 50 mm parallel to fibre dimension. After cutting, the CFRP chips must be distributed rather uniformly over a backing paper to obtain a raw uncured sheet of about 500 mm x 1000 mm to be subsequently used as raw material to produce light weight structural elements or tooling.
The objective of the project is the development and realization of equipment modules that are able to cut and distribute uniformly the above chips, according to the following requirements.
The cutting module shall be able to:

- be rechargeable of CF scarps in a continuous manner;
- be easy to maintain;
- cut both in the longitudinal and transverse directions in a precise and clean way;
- avoid winding the cut strips on the cutting blades;
- have all equipment cooled;
- have continuous cutting;
- have simple construction;
- have capacity to operate even in presence of a different scraps geometry;
- have a system able to verify the correct orientation of the fibers in input to the system;
- integrate perfectly with the distribution module.

Instead, the distribution module has to be able to receive CFRP rectangular chips coming from cutting stage with rather constant rate and to, at random, orient and distribute the chips over a plate covered by a suitable baking paper (sheet will have a dimension of 500 x 1000 mm).
In addition, the distribution module shall ensure:

- final CFRP material aerial weight of 1000 (+/-200) gr/sqmt;
- quasi isotropic fibre orientation; i.e. 0°: 25 (+/-5)%, +/-45:50 (+/-5)%, 90°:25 (+/-5)%;
- plant productivity equal to: 2.5 ÷ 4.5 kg/h (for the first prototype, a lower productivity is allowed);
- The total working flow shall not exceed 8 h (including defrosting time of raw materials).

Finally the modules have not to contaminate or alter CFRP chips and in particular the distribution system must ensure repeatability of the properties of the material that generates as output (with the possible presence of a dedicated control system and auto-calibrated device). Anyway the machine shall process the material into temperature and humidity controlled environments.
Only allowed contact materials will be used and any process that can heat or cool or wet the materials shall be reviewed by Topic Manager before application.
The raw material needed for the execution of overall project will be provided to the applicant by Topic Manager

in frozen sealed bags. The main characteristics of this raw material are listed below:

- single layer (thickness range 0.1 ÷ 0.3 mm);
- irregular shapes ;
- epoxy resin;
- standard intermediate and high modules CF;
- prepeg layer supported by backing paper or backing polyethilene film (if any).

2.1. Work Breakdown Structure

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

WP	*Title*
WP1	***Trade-off Study***
Task 1.1	Feasibility studies for overall recycling equipment
Task 1.2	Trade-off between different approaches
Task 1.3	Main parameters and key components definition for the selected process
Task 1.4	Definition of suitable method for fiber areal weigh and fiber orientation distribution measurement for recycled material
WP2	***Design and Manufacturing***
Task 2.1	Detail design of recycling equipment (cutting and distribution modules)
Task 2.2	Fabrication of equipment modules
Task 2.3	Integration of recycling equipment modules (cutting and distribution systems)
Task 2.4	Feasibility tests for recycling equipment validation
Task 2.5	Recycled material basic structural characterization

2.2. WP Description

WP1 - Trade-off study

Task 1.1 - Feasibility studies for overall recycling equipment
The objective of the task is to identify different methods/mechanisms for chips cutting and distribution; i.e. blades geometry, knives and counter knives, mat belts and rollers, air stream, vibrating tables etc.
For each method, the key parameters and components shall be identified. In this task, the geometrical constraints that impact the overall system need also to be defined.

Task 1.2 - Trade-off between different approaches
The different methods/mechanisms shall be compared in terms of compliance with the requirements described above and costs, and the most suitable for implementation will be selected. This task involves a close interaction with the Topic Manager to check compatibility with the overall proprietary system.

Task 1.3 - Main parameters and key components definition for the selected process

In this task, the parameters and key elements of the equipment for the selected approach will be completely defined.

Task 1.4 - Definition of suitable method for fiber areal weigh and fiber orientation distribution measurement for recycled material

The task will be in particular devoted to define suitable methods to measure fiber areal weight and fiber orientation distribution in at least 20 square zones (dim. 100 x 100 mm) randomly identified into the resulting CFRP sheet after material recycling. Alternative method can be proposed by the applicant based on a statistic approach of relevant measures taken on the entire CFRP sheet.

WP2 - Design and Manufacturing

Task 2.1 - Detail design of recycling equipment (cutting and distribution modules)

The task will be devoted to the detailed design of cutting and distribution modules. The output of the task will be the related drawings.

Task 2.2 - Fabrication of equipment modules

The task will be devoted to the fabrication of a working cutting and distribution modules. In order to assess process parameters, prototypal modules shall be fabricated and tested in advance.

Task 2.3 - Integration of recycling equipment modules (cutting and distribution systems)

The task will be devoted to the integration of the longitudinal/transversal cutting module with the distribution module.

Task 2.4 - Feasibility tests for recycling equipment validation

The objective of the task is to perform functional and operative tests in order to verify the feasibility of recycling equipment and that all the requirements mentioned above are met. To demonstrate that, at applicant site, a production of a minimum of 10 sheets of recycled material shall be performed (starting from CFRP uncured scraps) and in particular CFRP areal weight and fiber distribution shall be verified as defined into Task 1.4. In addition production rate shall be verified according to requirement described above

After completion of the task, the overall equipment shall be transferred and installed on Topic Manager plant.

Task 2.5 - Recycled material basic structural characterization

Once verified the correct functioning of the system in terms of repeatability of the production of the recycled material, some panels shall be laminated and cured in order to extract specimens (approximate number of coupons: one hundred) for preliminary mechanical characterization of the recycled material. Tension, compression, Filled Hole Tension, Open Hole Compression, Unnotched Tension, Unnotched Compression, Interlaminar Plane Shear are the main properties to be verified.

Recycled sheets will then be produced and inspected at Topic Manager site in collaboration with applicant. Panel lamination, bagging and autoclave cure are under Topic Manager responsibility. The applicant must take care of coupons cutting, testing and data reporting.

2.3. Intellectual Property

The text of this topic contains the basic information for the applicant to understand the need of the Topic Manager.

However, more detailed data will be available in a separate info package that can be provided on request to the interested applicant. Due to the confidential content of this additional information, it will be necessary to sign a Non-Disclosure Agreement (NDA) with the Topic Manager Company. Questions concerning the confidential data delivered will be handled in a dedicated Q/A document, which will only be circulated to those applicants who have signed the Confidentiality Agreement.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables to be provided are listed in the table below:

Deliverables			
Ref. No.	***Title - Description***	***Type (*)***	***Due Date***
D1	Definition of possible approaches	R	T0 + 6
D2	Selection of most suitable approach and definition of key parameters/components	R	T0 + 9
D3	Measurement of fibre areal weigh and fibre orientation module definition	R/D	T0 + 18
D4	Detail design of recycling equipment (cutting and distribution modules)	R/CAD	T0 + 21
D5	Fabrication of equipment modules and integration of recycling equipment module	R/D	T0 + 27
D6	Functionality and feasibility tests of recycling equipment	R/D/T	T0 + 33
D7	Material basic structural characterization activities	R/T	T0 + 36

Main Milestones are listed in the table below:

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type (*)***	***Due Date***
M1	Definition of equipment components	RM	T0 + 9
M2	CDR of cutting and distribution module	RM	T0 + 21

M3	Cutting and distribution modules on site in Topic Manager facility	RM	T0 + 33
M4	Structural recycled material characterization	RM	T0 + 36
M5	Contribution to Project final assessment	RM	T0 + 36

***Type:** R: Report - RM: Review Meeting - D: Delivery of hardware/software - CAD: Computer-aided design T: Test*

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

- ✓ 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.
- ✓ Experience and skills acquired from projects focused on similar tasks.
- ✓ Quality and risk management capabilities demonstrated through applications on international R&T projects and/or industrial environment.
- ✓ Proven experience in the use of design, analysis and configuration management tools.
- ✓ International proven experience development projects combined with wide expertise in management of research first level work package.
- ✓ Proven competence in drawings and realization of mechanical device for uniform distribution of chips in any other fields and/or have a know-how on specific technique useful for the above application.
- ✓ General knowledge of uncured composite material storage and handling conditions.
- ✓ Proven experience in experimental testing.
- ✓ Proven experience in the Industrial Automation field.
- ✓ Proven experience in the detection field.
- ✓ Competence in measures and data analysis with statistical approaches.
- ✓ Testing skills to allow mechanical and chemical characterization of samples made by new technologies.

5. Clean Sky 2 – Engines ITD

I. Optimisation of sensor and associated data acquisition system for blade behaviour

Type of action (RIA or IA)	IA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP 2		
Indicative Funding Topic Value (in k€)	1800 k€		
Duration of the action (in Months)	36 months	**Indicative Start Date**[43]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-ENG-01-05	**Optimisation of sensor and associated data acquisition system for blade behaviour**
Short description	
Blade Tip Timing is a key tool for blade health assessment without any instrumentation on the rotating parts. It is often used for fan and compressor survey in test cell but it is a complex system that is not compatible with an embedded solution or harsh environment. The aim of this CFP is to optimize the current system in order to be able to embed it and monitor all kind of blades during commercial flight.	

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

1. Background

The ability to monitor the structural health of the rotating parts, especially in the hot sections of turbine engines, is of major interest to aero community in improving engine reliability.
Most of the tip timing measurement systems are designed for test conditions and used to assess blade behaviour.

These measurements require sensors which require an adaptation of housings:

- Proximity sensors
- Optical probes

Data acquisition system is installed in the test bench and is not removed.

Blade monitoring is a key to assess their behaviour during ground tests, flight tests but also in operation to detect premises of failure. The advantage of this technique is that it does not require any sensor on the rotating environment as sensors are only in the non-rotating parts. On the blade, there is no wire or additional weight that could be centrifuged and ingested by the engine.
Tip Timing is one of the most efficient techniques to monitor blade behaviour. It is a well known technology for fan blade monitoring during tests but it requires several sensors, a high frequency data acquisition and a high CPU/RAM usage. It is possible to optimize these algorithms as Health Monitoring needs are not the same as Ground test needs: Ground tests require a "complete" characterization of the blade behaviour whereas health monitoring focuses on first modes shifts. A difficulty is that first modes are only visible during transient phases that are very short during in service life.
Aims of this CFP for Fan blades embedded health monitoring are:

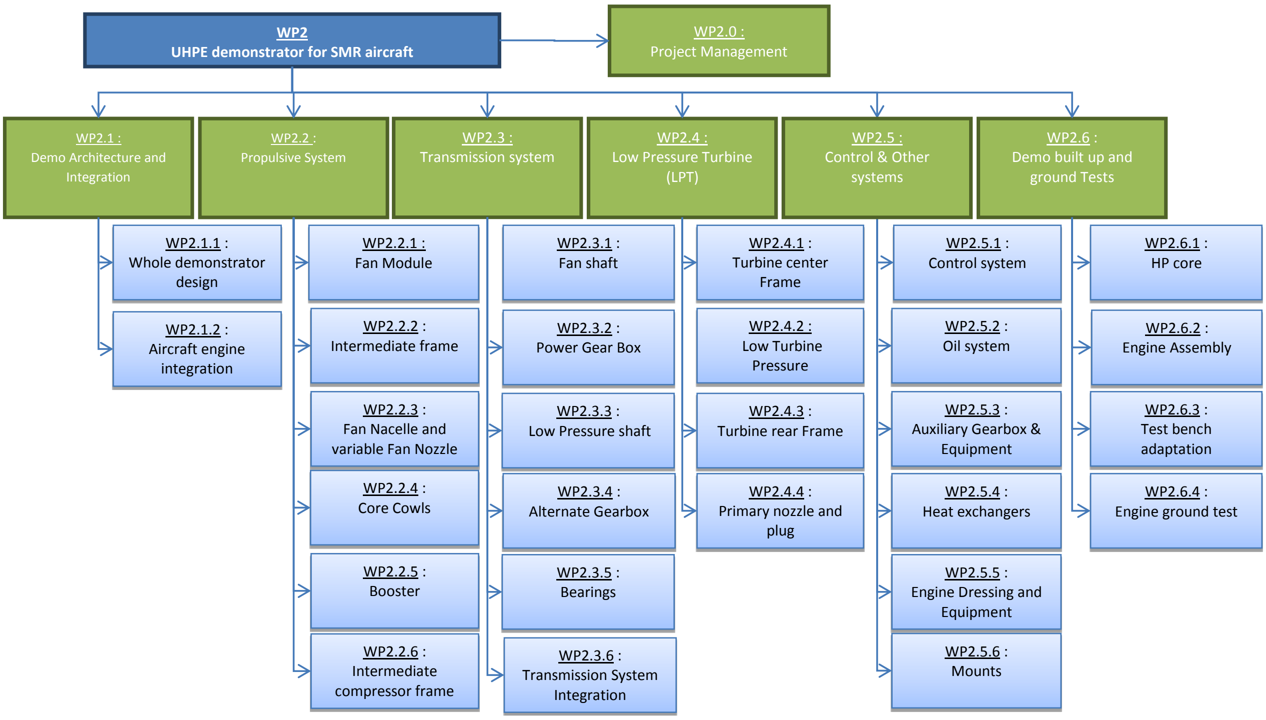
- optimization of the number and location of sensors, optimization of data acquisition and Tip Timing algorithms to be compatible with a quite real time monitoring in an embedded system

For Turbine and Compressor blades the problem is different and the aim is to develop a ground test bench solution for "complete" characterization of blade behaviour. Due to special shapes and high rotation speed, this kind of Tip timing is much more difficult than for fan blades.
Aims of the CFP for Compressor and Turbine blades surveillance for ground tests are:

- Development of Tip Timing techniques compatible with these blades shape and associated signals,
- Development of Tip Clearance techniques compatible with these blades shape and associated signals,

Note: Fan Blade Tip Clearance is well known and does not need to be optimized

The breakdown in this WP2 is the following:



2. Scope of work

The partner will propose an optimized algorithm (or several, one for each kind of blade) compatible with an embedded system and that can be applied for the monitoring of Fan, Compressor or Turbine blades.

The perimeter of the study should include at least:

- For Fan blades embedded health monitoring by Tip Timing :
  - Optimization of the number and location of sensors,
  - Optimization of data acquisition,
  - Optimization of algorithms,

The aim is to make a solution compatible with an engine embedded system.

It shall be highlighted that fan blade health monitoring does not require to completely characterize blade behaviour with Tip Timing. Blade Health monitoring requires to check that first frequency modes do not shift more than a few percent. Note these first frequency modes are visible during very short transient phases but not in permanent state.

- For Turbine and Compressor blades surveillance during ground test bench :
  - Development of Tip Timing algorithm compatible with these blades shape and associated signals,
  - Development of Tip Clearance algorithm compatible with these blades shape and associated signals,

Contrary to Blade Health Monitoring, Compressor & Blade surveillance during bench tests requires "complete" characterization of blade behaviour but requires less algorithm optimization (first application will be on ground). The main problem for Turbine and compressor surveillance is that the signal is much more difficult to process (special shapes make blade signals less clear/marked).

The partner proposal (algorithm and location of sensors) will be validated on test bench. SNECMA will provide sensors and will adapt its housing in accordance with it (as long as it is possible considering instrumentation constraints).

SNECMA will provide to the partner the following data:

- Simulated data
- Real test data with location of sensors

DIAGRAMME GANT - UHPE – Tip Timing Embedded		2017				2018				2019			
REF	Label	1	2	3	4	1	2	3	4	1	2	3	4
1	CFP MOUNTS												
T0	Tip Timing embedded - Management and reporting												
T1	Tip Timing embedded - Risk reduction plan												
M1	Tip Timing embedded - Risk reduction plan review												
M5	Tip Timing embedded - Risk reduction plan : Completion review												
T2	Tip Timing embedded - Contribution to specification												
M2	CS2/WP2 - D1 : Software requirements Review												
T3	Tip Timing embedded - Software Design and Unit Tests Plan definition												
M3	CS2/WP2 - M2 : Software Preliminary Design Review and Unit Tests Plan Review												
M4	CS2/WP2 - M3 : Software Design Review												
T4	Tip Timing embedded - Unit tests												
M5	Tip Timing embedded - Software delivery for engine demo (FAN)												
T5	Tip Timing embedded - Performance evaluation (FAN blades)												
M6	Tip Timing embedded - Software delivery for engine demo (Turbine and compressor blades)												
T6	Tip Timing embedded - Performance evaluation (Turbine and Compressor blades)												
TRL					3			4					5

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 0	*Tip Timing embedded - Management and reporting* **Progress Reporting & Reviews:** ● Quarterly progress reports in writing shall be provided by the partner, referring to all agreed workpackages, technical achievement, time schedule, potential risks and proposal for risk mitigation. ● Monthly coordination meetings shall be conducted via telecom. ● The partner shall support reporting and agreed review meetings with reasonable visibility on its activities and an adequate level of information. ● The review meetings shall be held at the topic manager's facility. **General Requirements:** ● The partner shall work to a certified standard process.	T0 + 36 months
Task 1	*Tip Timing embedded - Risk reduction plan* To provide and achieve a plan including test and capability demonstration for each technical element.	T0 + 18 months
Task 2	*Tip Timing embedded - Contribution to specification* To contribute to the requirements written under SNECMA leadership.	T0 + 6 months
Task 3	*Tip Timing embedded - Software Design and Unit Tests Plan definition* To perform preliminary design complying with the specifications provided by SNECMA and to define Unit Tests Plan.	T0 + 15 months
Task 4	*Tip Timing embedded - Unit Tests* To perform unit tests with simulated data and real tests data provided by SNECMA.	T0 + 21 months

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 5	*Tip Timing embedded - Performance evaluation (FAN blades)* To perform Tests on engine or partial test bench with SNECMA.	T0 + 30 months
Task 6	*Tip Timing embedded - Performance evaluation (Turbine and Compressor blades).* To perform Tests on engine or partial test bench with SNECMA.	T0 + 36 months

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type (*)***	***Due Date***
D1	*Management plan*	R	T0 + 2 months
D2	*Software Requirements*	R and RM	T0 + 6 months
D3	*Risk reduction plan completion – Test Report*	R	T0 + 21 months
D4	*Software Preliminary Design Review (SPDR)*	R and RM	T0 + 9 months
D5	*Software Design Review (SDR)*	D	T0 + 15 months
D6	*Software delivery* (FAN)	D	T0 + 21 months
D7	*Software delivery* (Turbine and Compressor)	D	T0 + 30 months
D8	*Performance evaluation on engine test - final report and synthesis*	R and RM and D	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	*Risk reduction plan Revue*	RM	T0 + 3 months
MS 2	*CS2/WP2 - D1 : Specifications*	RM	T0 + 6 months
MS 3	*CS2/WP2 - M2 : SPDR*	RM	T0 + 9 months
MS 4	*CS2/WP2 - M3 : SDR*	RM	T0 + 15 months
MS 5	*Risk reduction plan Completion review*	RM	T0 + 21 months
MS 6	*CS2/WP2 - D2 : engine ready for engine tests*	RM	T0 + 21 months

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

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

- ✓ Experience in sensors is an asset
- ✓ Experience in Tip Timing is an asset
- ✓ Experience in rotating blade vibrations is an asset
- ✓ Experience in advanced data processing and math/stat algorithms is mandatory
- ✓ Experience in aircraft engine instrumentation is an asset
- ✓ English language is mandatory

II. Very high loaded planet bearings enabling technologies

Type of action (RIA or IA)	IA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP 2.3.4		
Estimated Topic Value (funding in k€)	500 k€		
Duration of the action (in Months)	36 months	**Indicative Start Date**	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-ENG-01-06	**Very high loaded planet bearings enabling technologies**
Short description (3 lines)	
In order to accomplish reduction of fuel burn, emission and noise, very high bypass engines are foreseen in the aeronautical engine perspective. These engine layouts will need a speed reduction system between the low pressure turbine shaft and the fan, having the complete power flowing in the reduction system. Therefore, in order to allow the feasible installation in the engine, high power density gearboxes are foreseen. In such a context, to enable higher ratio planetary configurations, the bearing underneath the planet is expected to exhibit very high roller speeds. Dynamic issues have to be thoughtfully assessed. Therefore a technology exploitation of low density roller materials, as ceramic ones, and a deep knowledge of cage – roller – planet interaction is a pivot point for enabling bearing reliability. Moreover higher oil temperature will characterise new gearboxes usage, and lower heat generation is demanded for increasing further the system efficiency and to avoid excessive oil heating. The applicant should analyse the planet bearing requirements provided by the topic manager, propose a design, develop a relevant testing plan for cage and roller elementary testing, and then for a subscale spherical roller bearing. Through the results of the testing activities, the applicant should validate the design also using its own specific dynamic bearing simulation capabilities confirmed by subscale testing.	

1. Background

Beyond 2020, new efforts are needed to achieve the ACARE goals for the year 2035 and – on a longer perspective – the 2050 targets of a 75% reduction in CO2 emissions, a 90% reduction in NOx emissions and a 65% reduction of the perceived noise in reference to Narrow Body engine performance of year 2000.

Clean Sky 2 will enable a natural continuation of the progress achieved since the first Clean Sky program creating cleaner aviation solutions for the near future. Clean Sky 2 will build on the work done in the Sustainable and Green Engines (SAGE) activities to validate more radical engine architectures. In particular, Ultra High Propulsive Efficiency (UHPE) program provides the opportunity to develop new technologies for aircraft turbofan engines that will be introduced into the market around the year 2025.

The Ultra High Bypass Ratio (UHBR) technology has the potential for significant reduction in fuel burn, emissions and perceived noise to the level defined by ACARE 2035. The challenging requirements of fuel consumption and noise emission could be achieved leveraging the Short/Medium Range (SMR) applications on areas not yet fully exploited. Overall turbofan engine efficiency is defined as combination of thermal efficiency and propulsive efficiency.

Increasing the thermal efficiency has been key strategy for most engine manufacturers so far to improve overall engine efficiency, whereas increasing the propulsive efficiency by significantly increasing the by-pass ratio, has been just recently undertaken. Current designs are reaching their limit in terms of thermal efficiency due to combustor and turbine materials heat resistance, whereas the propulsive efficiency path is still to be further explored.

The Ultra High Bypass Ratio technology achieved with the geared turbofan concept – that decouples fan and turbine speeds by means of an Integral Drive System (IDS) – is an innovative architecture that can enable significant reduction in fuel burn, noise and emissions benefits while allowing a reasonable core and engine size.

This provides opportunity for both upgrading current generation of Narrow Body airplanes with next generation engines and introducing engines for next generation aircrafts.

The objective of BesIDeS project is to design, develop and test an innovative drive system by introducing a power gearbox with breakthrough technologies for the Ultra High Propulsive Efficiency Demonstrator. Today geared turbofan engines are developed by US OEM only; BesIDeS project is providing a unique opportunity for European companies to leverage their technical experience and competitiveness to set up a collaborative environment in which integration of main modules can be optimized to reach higher level of performance.

The ITD-WP2 aims at developing and testing the UHPE demonstrator substantiating the UHBR concept as solution to meet future emission and noise targets. Its action concentrates on developing EU based technology for UHBR ducted geared turbofan architecture with a by-pass ratio preliminary anticipated in the range 15-20. The program will mature a set of specific technologies dedicated to the UHPE concept to TRL 5 by mid-2021. The program will end with engine ground test providing information about actual SFC and noise emission advantages of geared turbofan compared to conventional direct drive engine.

Within the UHPE program, BesIDeS project aims at designing and testing a breakthrough drive system with differentiating technologies matured up to TRL 5. The validation on the power rig and ground test demo will determine the reliability and mechanical performance of the module for UHPE engine architecture.

The BPR of conventional turbofan engine is limited by fan diameter and speed, which is equal to low pressure turbine (LPT) speed, due to common shaft connecting both modules. Higher BPR can be achieved by enlarging the fan, but only with a simultaneous decrease of fan speed (due to fan tip speed limit) and therefore of LPT speed which introduce a penalty related to turbine efficiency and weight/size (higher number of stages).

The geared turbofan configuration is a promising alternative to conventional engine layout. It introduces a decoupling between the LPT and the Fan by means of a power gearbox, thus enabling separate optimization of both systems. The next generation of geared turbofan will allow for bigger diameter fan rotating at lower speed coupled with a higher speed LPT which will have higher efficiency and lower number of stages.

The power gearbox is the enabler allowing difference between conventional and next generation turbofan engines; it is a new engine core module to be included in the optimization of the whole engine to achieve maximum overall performance. The Ultra High Bypass Ratio technology combined with the geared turbofan is an innovative architecture that can enable significant reduction in fuel burn, noise and emissions benefits while allowing a reasonable engine and core size..

Therefore the table below summarize the main technical requirements:

Power gearbox Layout	1 input/1 output
Power gearbox Power to weight ratio:	>75 kW/kg

Starting from the terms of reference described by the Program Leader, an activity aimed at identifying the main CTQs has been performed. The captured targets will be used as guidelines for conceptual module design and have been accounted for the identification of required key technologies. In particular, the following CTQs were captured as priority for the BesIDeS project success:

- High Power Density;
- Low Maintenance, High Reliability, Long Life;

• Module Efficiency.

Attention will be focused on maturing differentiating technologies and processes that would be introduced in the innovative drive system module for UHPE demonstrator. Among these technologies are high load and long life planet bearings, resulting in lower overall module weight, higher efficiency and improved reliability.

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:

T1 Bearing solution and bearing designs

In this task the input will be responsibility of the topic manager that will provide to the applicant requirements in terms of available design space, load cycles (including centrifugal field), speed cycles, the expected reliability, the oil type and flow, the expected temperature field, and other detailed targets and constraints. The topic manager will propose bearing material and heat treatment.

T1.1 Preliminary solutions and design

This task will be responsibility of the applicant that, using appropriate means of calculation and its engineering experience will propose to the topic manager a planet bearing design, i.e. the target and preliminary nominal values of:

- detailed inner and outer raceways size, 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. Material is expected to employ a Si_3N_4 material base.
- the cage size, its guiding diameter, the cage slot size and material characteristics (density, other mechanical expected properties)

The applicant shall motivate the choices and substantiate them through calculation estimates based on requirements.

The topic manager will approve and concur to the preliminary design.

T1.2 Detailed bearing definition

This task will be responsibility of the applicant that, using appropriate means of calculation, its engineering experience and performed tasks so far, will either confirm the design developed in task

1.1, or will propose an improved design.
Additional values have to be provided to the topic manager, as for example:

- rollers porosity, fracture toughness, bend testing limit, inclusions density, fluorescent penetrant inspection acceptable indication limit
- cage fracture toughness

The deliverable will include both the nominal values and tolerance fields.
The topic manager will approve and concur to the detailed design.

<u>T2 Materials and technologies for bearing function</u>
In order to demonstrate the feasibility of the proposed design, advanced technologies will be tested in subscale testing activities that will focus on main key components of the bearing.

<u>T2.1 Process development for ceramic spherical roller</u>
The applicant shall propose a subscale ceramic roller design (including details listed in T1.1) and a test plan to the topic manager, in order to demonstrate the reliability of the design and specifically of the manufacturing process of the spherical roller. The topic manager will approve the test type, plan and test articles.
The applicant will procure the T/A and will perform the appropriate tests and will report periodically to the topic manager the test results.

<u>T2.2 Elementary / subscale testing campaign for cage</u>
The applicant shall propose a cage design (including detailed material composition, density, toughness) and a test plan to the topic manager, in order to demonstrate the reliability of the design and specifically of the manufacturing process of the cage. The topic manager will approve the test type, plan and test articles design.
The applicant will procure the T/A and will perform the appropriate tests; the applicant will report periodically to the topic manager the test results.

<u>T2.3 Elementary / subscale testing campaign - SRB screening</u>
After a preliminary screening of ceramic roller and cage design, material and manufacturing processes, the applicant shall provide to the topic manager a proposal of a subscale bearing test article and a related test plan that will assess the final combination of ceramic roller and improved cage.
The topic manager will approve the test type, plan and test articles design.
The applicant will procure the T/A and will perform the appropriate tests; the applicant will report periodically to the topic manager the test results.

<u>T3 Lubrication design</u>
The topic manager will be responsible for providing a proposal for the bearing lubrication inlet area. Then, the applicant shall perform adequate multiphase CFD calculations in the rotating roller/cage/race bearing volume, taking into account also the centrifugal field, in order to adequately design the lubrication of the bearing, in terms of flow amount and direction. Target is optimising

convective heat transfer and minimising heat generation. The applicant shall also consider modifications to the design due to lubrication calculation results. The applicant shall consider also potential coating application or advanced texture features.
Cage/cage guiding surface contact shall also be considered.
Steady and transient conditions, as engine start and attitude effects on oil distribution shall also be simulated.
The applicant shall substantiate the design modification proposals through heat generation and heat transfer calculations to the topic manager that will eventually concur and approve the modifications.

T4 Dynamic bearing solution: design and computation

The applicant shall propose to the topic manager a complete planet bearing dynamic contact model of the target bearing design that will account for:
- actual contacts between deformable raceways and rollers, taking into consideration the transient and then steady lubrication conditions as defined in task T3
- actual contacts between deformable cage slots and rollers, taking into consideration the potential impacts and cage behaviour in full centrifugal field
- actual contacts between raceways and cage, taking into consideration the transient and then steady lubrication conditions of lubrication of the cage guiding surface as defined in task T3
- the inertias and stiffness of the pin and planet rim (also considering planet rim-roller interaction and stiffening due to tooth form).
- the effective inertia and stiffness of the carrier, the ring and the sun shafts, considering all the local compliance variations.
- damping of the system
- stick and slip effects

The topic manager will approve the simulation requisites. The applicant will prepare the model and run the simulations, providing results to the topic manager.
An example of the expected load conditions to be simulated are:

Steady conditions: resonances estimate

Steady endogenous effects that provide system excitation: stiffness variation due to roller passing effects and meshing cycles phases.

Transient exogenous effects: engine start and shutdown, off-axis load, fan blade out resulting unbalance, attitude effects on oil distribution, etc

The output of the simulation available to the topic manager will include loads, deformation and stresses on raceways, rollers, cages. Moreover, the applicant shall deliver an engineering judgement regarding the bearing reliability in the simulated dynamic conditions, and provide to the topic manager a dynamic factor estimate in order to let it evaluate other components dynamic supplemental load.

T4.1 Dynamic modeling of the planet without gearbox

In this task the applicant shall model the planet bearing dynamics assuming simplified tooth load interaction in a single planet bearing.

T4.2 Dynamic modeling of gearbox architecture

In this task the full gearbox architecture will be modelled, including all the planets, the gears (sun to planets, planets to ring meshes), the carrier (in its stiffness and mass), the sun (in its carrier and mass). Interaction among components (e.g. also between different planets) has to be accomplished through accurate modelling.

The applicant – after the complete model has been built – will provide to the topic manager the full dynamic gearbox model model and the technical software able to run it in as a closed "black box", i.e. without any change possible in the bearing model. The model will be available to the topic manager that will eventually run it using different exogenous conditions. Available output of the model will be defined jointly by the applicant and the topic manager.

T4.3 Model validation from SRB testing

In this task the applicant shall develop the subscale SRB dynamic model and validate it through the testing results

Tasks		
Ref. No.	***Title - Description***	***Duration***
T1	Bearing solution and bearing designs	Mo1-Mo24
T1.1	Preliminary solutions and design	Mo1-Mo6
T1.2	Detailed bearing definition	Mo16-Mo24
T2	Materials and technologies for bearing function	Mo1-Mo30
T2.1	Process development for ceramic spherical roller	Mo1-Mo27
T2.2	Elementary / subscale testing campaign for cage	Mo2-Mo24
T2.3	Elementary / subscale testing campaign - SRB screening	Mo2-Mo30
T3	Lubrication design	Mo10-Mo24
T4	Dynamic bearing solution: design and computation	Mo4-Mo24
T4.1	Dynamic modeling without gearbox	Mo4-Mo30
T4.2	Dynamic modeling of gearbox architecture	Mo10-Mo36
T4.3	Model validation from SRB testing	Mo4-Mo30

Mo: month from T0

3. Major deliverables and schedule (estimate)

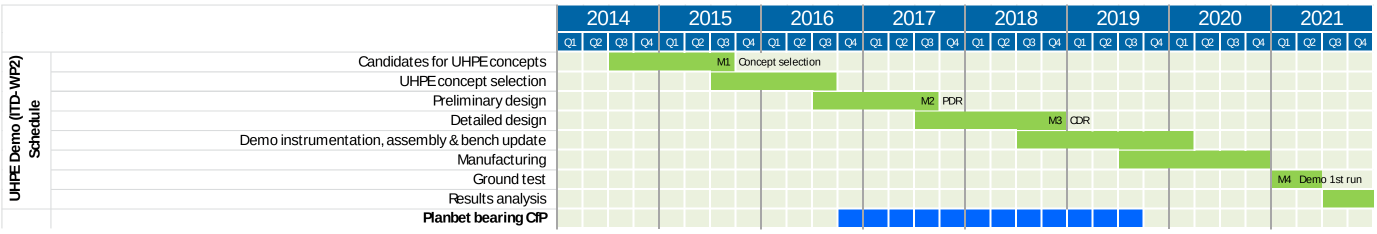
Deliverables			
Ref. No.	***Title - Description***	***Type (*)***	***Due Date***
D1	Preliminary gearbox bearing design drawings	R	T0+6 months
D2	Detailed bearing design drawings	R	T0+24 months
D3	Test plan and T/A for spherical roller definition report	R	T0+6 months
D4	Test plan and T/A for cage definition report	R	T0+6 months
D5	Test plan and T/A for subscale testing definition report	R	T0+6 months
D6	Interim report of process development activities for ceramic spherical bearing	R	T0+15 months
D7	Final report of process development activities for ceramic spherical bearing	R	T0+27 months
D8	Lubrication design assessment report	R	T0+24 months
D9	Dynamic model validation report	R	T0+30 months

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

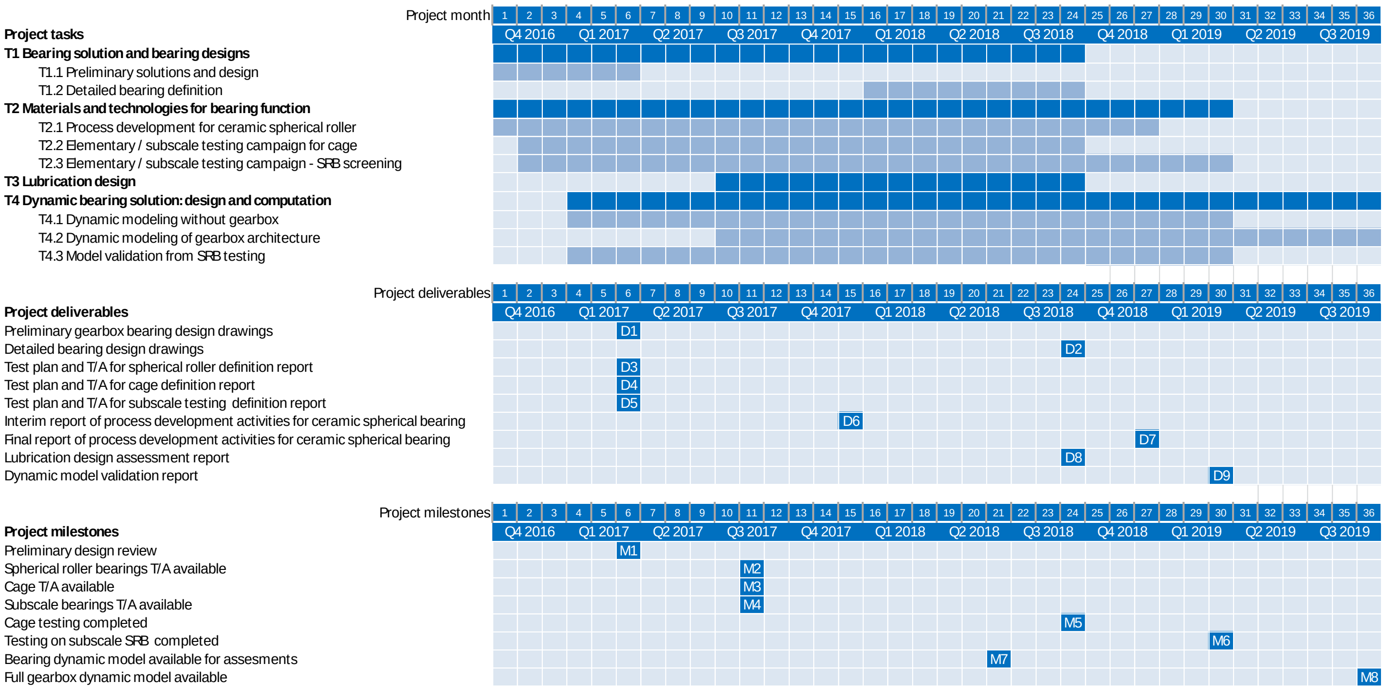
Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Preliminary design review	RM	T0+6 months
M2	Spherical roller bearings T/A available	D	T0+11 months
M3	Cage T/A available	D	T0+11 months
M4	Subscale bearings T/A available	D	T0+11 months
M5	Cage testing completed	R	T0+24 months
M6	Testing on subscale SRB completed	R	T0+30 months
M7	Bearing dynamic model available and validated	R	T0+21 months
M8	Full gearbox dynamic model available	R	T0+36 months

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

For information overall demonstrator schedule:



Schedule for Topic Project (Level 2 Gantt):



4. Special skills, Capabilities, Certification expected from the Applicant

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:

Bearings:

- ✓ Extensive experience in development of bearings for high performance aerospace application. Proven experience in aerospace bearing development for equivalent applications.

- ✓ Proven experience in application of bearing technologies to gears and integration of bearing design with gears.
- ✓ Successful experience, with demonstrable benefits, of application of innovative technologies to gears is an asset. Availability of technologies at an high readiness level to minimize program risks is an asset.
- ✓ Proven experience in transient dynamic simulation of bearings.
- ✓ 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).

III. Advanced mechatronics devices for electrical management system of Turboprop

Type of action (RIA or IA)	RIA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP3		
Indicative Funding Topic Value (in k€)	900 k€		
Duration of the action (in Months)	36 months	Indicative Start Date[44]	Q1 2017

Identification	Title
JTI-CS2-2016-CFP03-ENG-01-07	Advanced mechatronics devices for electrical management system of Turboprop
Short description	
An advanced electrical machine together with the electrical power management will be studied, designed & manufactured. Following partial tests at partner facility, demonstrator hardware will be delivered for engine ground tests.	

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

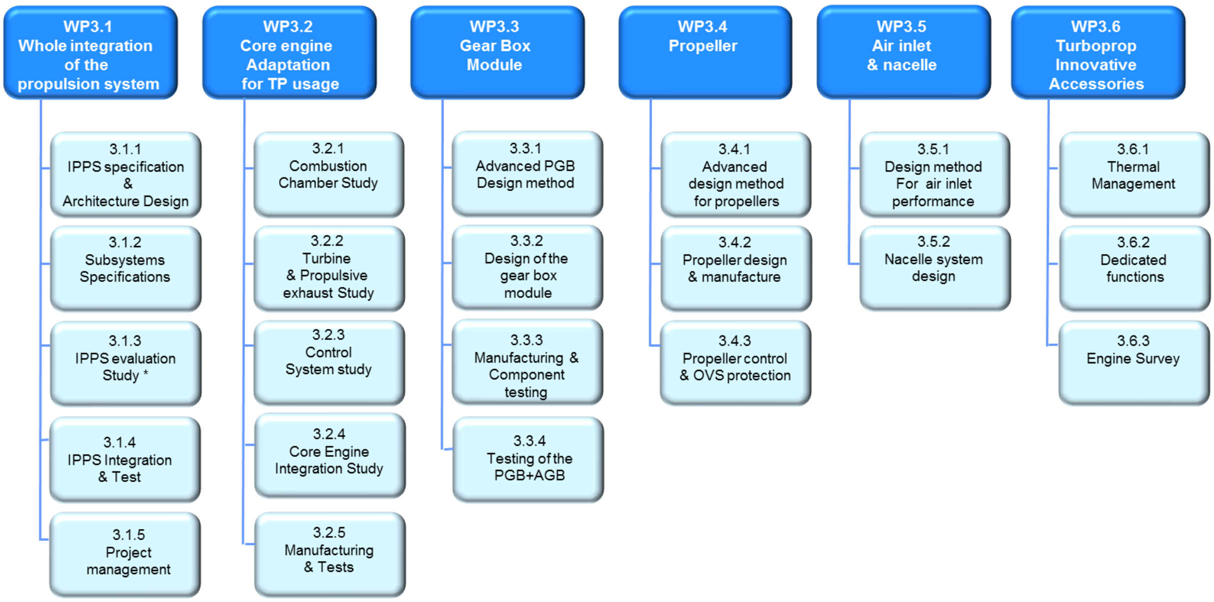
1. Background

WP3 targets the acquisition of technologies for a high performance turboprop in the 1800-2000 shp class which will significantly upgrade the actual product efficiency. This demonstrator will deliver technologies maturity up to TRL 5/6 in 2019 with capability to be part of the next generation of aircrafts.

The base line core of ARDIDEN3 engine will be improved specifically for turboprop application and then integrated with innovative gear box, new air inlet and innovative propeller and controls.

In this frame, the propeller control system incorporates more electrical components in order to improve the capabilities of electrical generation, weight, interface to aircraft and maintenance actions.

The figure below shows the project structure. The partner is expected to work within work packages WP3.6.2. He will also be involved in the workpackage WP3.1.4.



2. Scope of work

Context

Turboprops in the 1800-2000shp class currently have a conventional brushed 28Vdc generator. This equipment is generally reliable and allow an easy control of the output voltage level; but this generator is often heavy and has a low Time Between Overall (TBO).

The purpose is to provide a system with lower weight and additionnal functions.

The partner will be responsible for designing, manufacturing and testing an integrated and advanced mechatronics system, basically made of:

- An electrical power device
- Associated control electronics

The wole system will be integrated into the engine Power & Accessory Gear Box (PAGB) and will be tested during engine tests.

The system is mechanically driven by 2 concentric shafts:

- Shaft 1 (internal), nominal speed around 1700 RPM
- Shaft 2 (external), nominal speed around 18000 RPM

Functions

The system will perform the following functions :

- GENERATOR The system shall be able to operate as a generator, in order to provide at least 16kW continuous, with an output voltage of 28Vdc or 270Vdc. A trade off will be performed to choose the best level voltage.
- MOTOR The system shall be able to operate as a motor, in order to deliver a mechanical power of 16 kW to the outer shaft with an estimated torque of 20-28 Nm with an input voltage of 28Vdc or 270Vdc.
    - The generator and motor functions will not be operating simultaneously.
- POWER TRANSMISSION The system shall also be able to generate up to 1kW electric power to a device rotating with the inner shaft (shaft 1). It shall be possible to select the power level, at least ON/OFF, from the power electronics.
    - The power transmission function shall be able to operate in generator mode and in motor mode.
- DIAGNOSIS The system shall perform diagnosis in order to detect internal failures and inability to operate in either mode
- INTERFACE The system shall interface to another device, receiving orders and sending health condition. Communication means will be defined later.

Integration

The estimated mass of the mechatronics system shall be less than 10kg. The packaging of this features will be mutualized with the casings of the PAGB.

The size of the mechatronics system shall be minimized and such as to fit with an external diameter of 170 mm and a maximum length of 135 mm. The inner diameter shall not be lower than 85 mm.

Model

The partner will also be responsible for delivering a macroscopic dynamic model of each of the components, allowing Turbomeca to design and tune engine control laws. The software used shall be Simulink or Amesim.

Test support

Finally, the partner will support Turbomeca during engine tests preparation and execution.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
	T0	**Q4 2016**
Task 0	Project management and reporting	T0+36
Task 1	Concept studies (with TM)	T0+2
Task 2	Contribution to specifications (with TM)	T0+3
Task 3	Preliminary design	T0+10
Task 4	Detailed design	T0+12
Task 5	Production & functional tests	T0+20
Task 6	Support during engine tests	T0+30
Task 7	Environmental tests	T0+30
Task 8	Components dynamic models	T0+12

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables & Milestones			
Ref. No.	***Title - Description***	***Type (*)***	***Due Date***
D1	Specifications (contribution of partner and TM)	R	T0+3
D2.1	Preliminary dynamic models	D	T0+6
D2.2	Final dynamic models	D	T0+12
D3	Preliminary Design Review	RM	T0+10
R4	Critical Design Review	RM	T0+12
D5	Equipments delivery	D	T0+24
R6	TM engine tests preparation	RM	T0+24
D7	Component tests reports (including environmental tests)	R	T0+34

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

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

- ✓ EN 9100
- ✓ EASA PART 21
- ✓ Experience in design, manufacture, testing and certification of electric machines for aeronautics
- ✓ Experience in design, manufacture, testing and certification of power electronics for aeronautics
- ✓ Experience in dynamic system modelisation using AMESIM or SIMULINK
- ✓ English or French language

IV. Advanced Bearings for Turboprop engine

Type of action (RIA or IA)	IA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP3		
Indicative Funding Topic Value (in k€)	500 k€		
Duration of the action (in Months)	36 months	**Indicative Start Date**[45]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-ENG-01-08	**Advanced Bearings for Turboprop engine**
Short description (3 lines)	
Development & validation of advanced bearings to address more stressed environments (temperatures, pressures, loads) and more demanding engine configurations. New generation bearings are expected to be developed and manufactured: partial tests and advanced monitoring will be conducted by the partner prior to installation on the engine for ground testing.	

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

1. Background

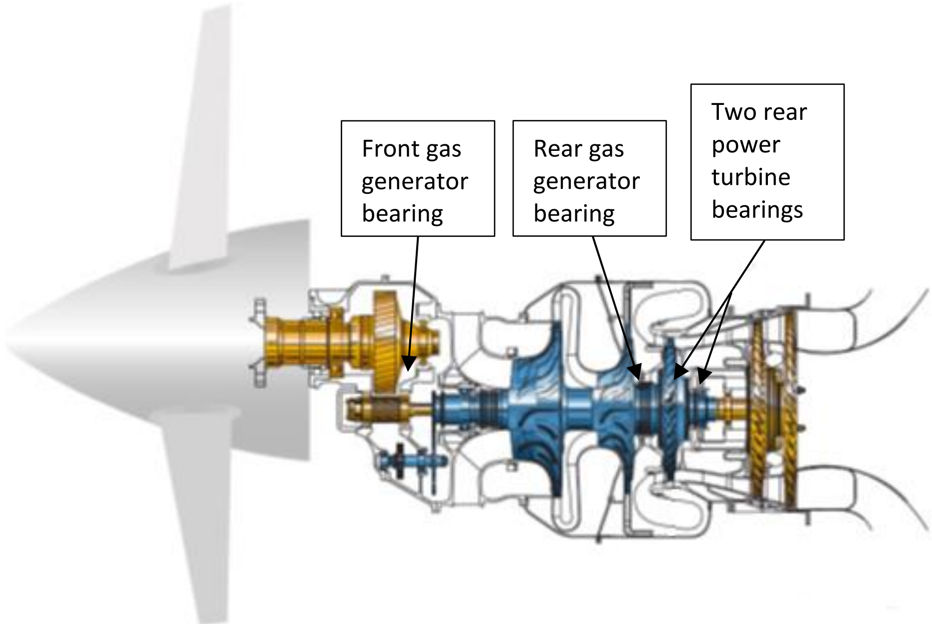
Engine reliability is one of the main focus for Safran/Turbomeca, which could be achieved through advanced bearings in order to increase their resistance to unwanted event like particle pollution or chemical contamination of the lubricant.
In order to do so, one of the prerequisite is to improve the level of knowledge regarding bearing usage conditions, and associated failure modes.
The TRL validation process and associated lead time is a constraint to be taken into account, and any possibility to shorten this process would be seen as a benefit.

2. Scope of work

The objectives of this Topic are:

- To identify, and deliver bearings with monitoring solutions in order to assess bearing usage conditions on an full engine test rig.
- To identify, manufacture bearings in advanced materials which would improve the resistance of the bearing to harch environments such as debris polluted and/or water polluted environments, and longer oil off conditions
- To run low TRL tests (up to TRL 5) in order to assess benefits from the advanced materials and advanced designs, and estimate new design limits
- To identify and propose an accelerated way to adress introduction of new bearing design and material technologies.

Bearings in the scope of the projects are:



Tasks		
Ref. No.	***Title - Description***	***Due Date***
	T0	Q1/2017
Task 0	Develop and validate monitoring solutions in order to assess bearing usage conditions.	T0 + 6 Months
Task 1	Delivery of bearings for engine testing and usage monitoring solutions: - Manufacture and deliver bearings for engine testing - The set of bearing needs to allow usage condition monitoring - Measurements made in engine will be processed in order to define bearing test conditions Bearings in the scope of the project are: - One 3 point of contact bearing, with squirrel cage - Two cylindrical Roller Bearings (CRB) - One cylindrical Roller Bearing with squirrel cage	T0 + 15 Months
Task 2	Development and validate monitoring solutions in order to asses failure mode detection in standard and degraded running conditions.	T0 + 36 Months
Task 3	Low TRL tests (up to TRL 5) of advanced bearing material and performance evaluation in terms of: - Fatigue resistance - Indentation resistance - Chemical pollution resistance - Power losses at high speed - Sliding Test should also provide evidence of no regression in terms of damage propagation in case of initiation compared to current standard material. Alternative bearing design improving the bearing resistance could also be proposed and tested.	T0 + 36 Months
Task 4	Identify strategies in order to increase the time to market of new material technologies	T0 + 4 Months

Tasks		
Ref. No.	***Title - Description***	***Due Date***
	T0	Q1/2017
Task 5	**Progress Reporting & Reviews:** • Quarterly progress reports in writing shall be provided by the partner, referring to all agreed work packages, technical achievement, time schedule, potential risks and proposal for risk mitigation. • Monthly coordination meetings shall be conducted via telecom. • The partner shall support reporting and agreed review meetings with reasonable visibility on its activities and an adequate level of information. • The review meetings shall be held at the topic manager's facility.	*T0+36*

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type (*)***	***Due Date***
D1	Task 0 : Technical reports showing the choices made for monitoring solutions	R	T0 + 6 Months
D2	Task 1 : Delivery of bearings for engine testing and usage condition monitoring solutions	D	T0 + 15 Months
D3	Task 2 : Synthesis report on development of monitoring solutions and failure detection sensing technology	R	T0 + 34 Months
D4	Task 3 : Comparative study of advanced materials and designs, pros & cons; selection of potential best in class solution	R	T0 + 12 Months
D5	Task 3 : Run low TRL tests, up to TRL4 Test report with results & analysis; data shall be made available in electronic format.	R	T0 + 24 months
D6	Task 3 : Run TRL 5 tests under tests conditions determined in Task 1 Test report with results & analysis; data shall be made available in electronic format.	R	T0 + 34 months
D7	Task 4 : Report with identified strategies in order to improve the time to market of new material technologies	R	T0 + 4 Months

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
MS 1	First Annual Review showing progress on each task	M	T0+12
MS 2	Second Annual Review showing progress on each task	M	T0+24
MS 3	Final Review with synthesis on each task (test results, experience gathered, lessons learned, proposals for improvement, etc.)	M	T0+36

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

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

- ✓ EN 9100
- ✓ Bearing design & manufacturing for aeronautics
- ✓ Bearing testing facility at high speed conditions for aeronautics
- ✓ Condition monitoring

V. Integrated Air Cooling Oil Cooled (ACOC) system

Type of action (RIA or IA)	IA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP3		
Indicative Funding Topic Value (in k€)	700 k€		
Duration of the action (in Months)	36 months	Indicative Start Date[46]	Q1 2017

Identification	Title
JTI-CS2-2016-CFP03-ENG-01-09	Integrated Air Cooling Oil Cooled (ACOC) system
Short description (3 lines)	
Design & manufacturing of an air-oil engine cooling system to be integrated in the engine bay. Demonstrator hardware will be delivered for engine ground tests. Integration study will be performed to assess the installation. A model for heat management will also be proposed.	

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

1. Background

WP3 targets the acquisition of technologies for a high performance turboprop engine in the power class below 2000 thermal shp. This demonstrator will deliver technologies maturity up to TRL 5/6 in 2019 with capability to be part of the next generation of aircrafts.

The base line core of ARDIDEN3 engine will be improved specifically for turboprop applications and then integrated with innovative gear box, new air inlet and advanced propeller.

The TP demonstrator will be installed at Turbomeca ground test facility. An Air Cooling Oil Cooled (ACOC) System must be designed and manufactured in order to be fitted onto the engine.

An illustration of a cooling system installation is presented in figure 1. The WP3 breakdown structure is shown in figure 2.

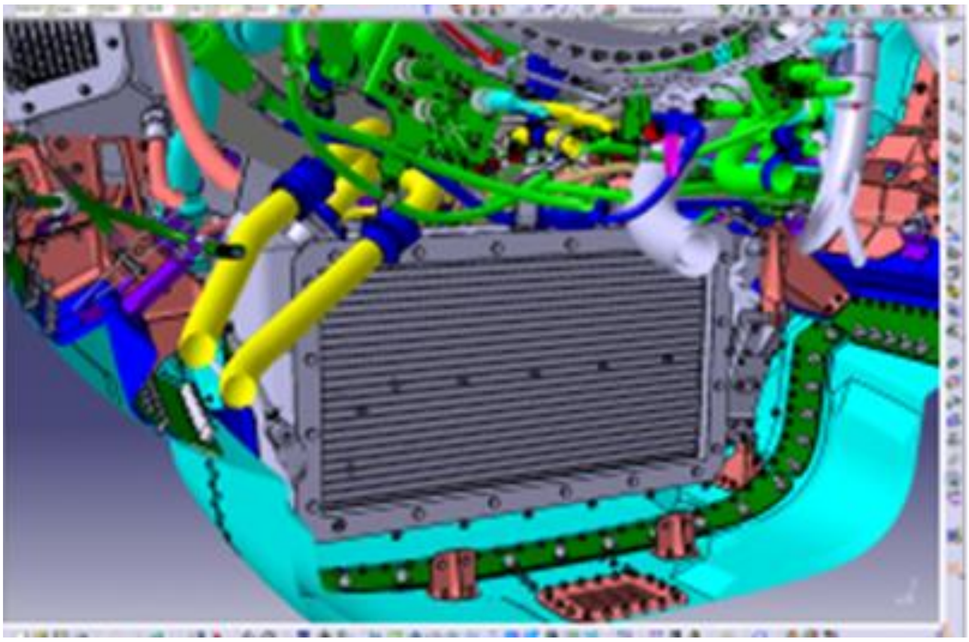


Figure 17: Illustration of Air-Oil Cooling System installation

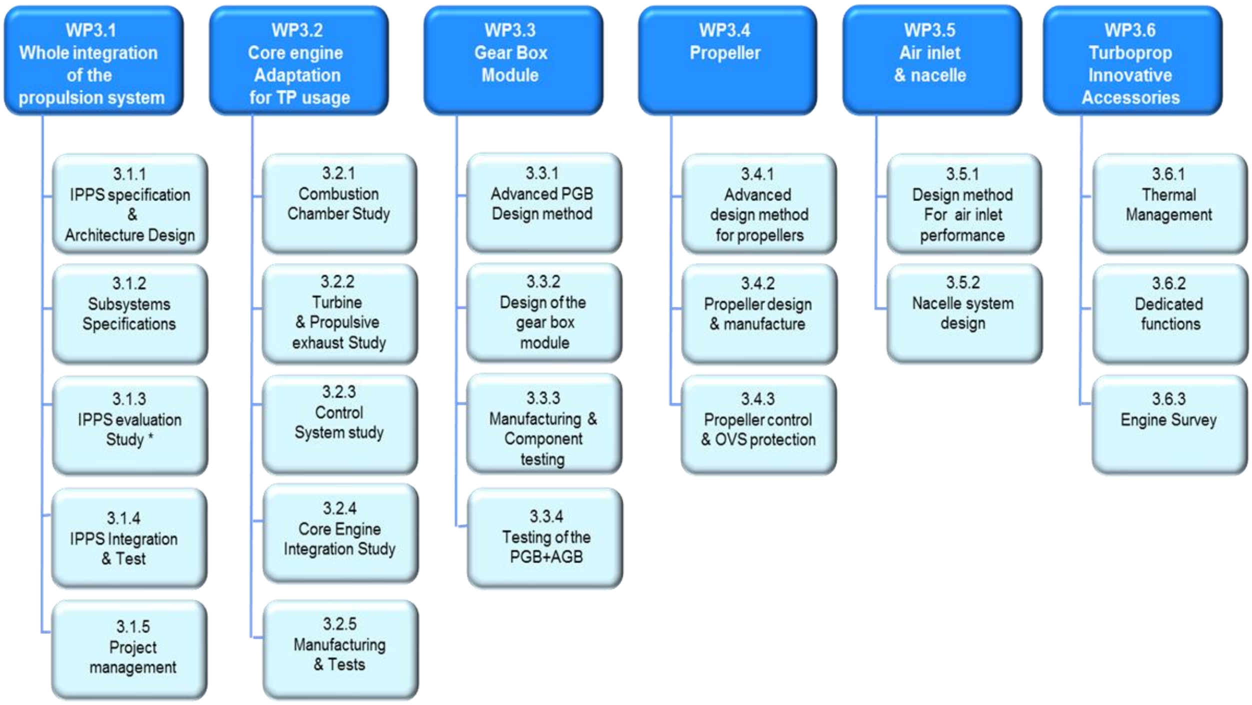


Figure 18: WP3 Workbreakdown structure

2. Scope of work

The scope of work of this CfP covers the perimeter of the Air Cooling Oil Cooled (ACOC) System. The applicant is required for participating in up-stream tasks as concept selection.

The applicant will design and manufacture the Air-Oil Cooling System for the engine ground tests. He will also work on assessing the integration & installation using numerical tools.

The instrumentation will be agreed between the applicant and the engine manufacturer.

The main tasks are listed below

- Perform and present a benchmark of in-service Air Cooling Oil Cooled (ACOC) System
- Design of an Air Cooling Oil Cooled (ACOC) System
- Integration topics (mechanical, inlet & outlet ducts to the system, cowl)
- Numerical simulations (hydraulic, structure & aerodynamics)
- 1D model simulation for heat management (AMESIM compatible tool)
- Manufacturing & delivery of one air-oil cooler
- Support during engine ground test

The main technical characteristics for the ACOC are listed below.

- Air Speed:
    - The design Point is given for the following conditions : engine at idle, hot weather conditions on ground, aircraft on ground & stopped, air flux limited to the propeller flux with an estimated air speed of below 10 m/s
    - Mean air speed at cruise condition ranging from 160 to 170m/s
    - Air inlet temperature : OAT versus Altitude (from -2000ft to 45000ft)
    - Air pressure losses: the value will be assessed before the call is closed.
- Oil flux:
    - Oil volume flow : from 1300 to 1700 Liter/hour
    - ACOC oil inlet temperature : 110°C
    - ACOC oil outlet temperature : 80°C
    - Oil pressure losses: the value will be assessed before the call is closed.
- Thermal power :
    - Thermal power to be dissipated : from 25kW to 30kW
- Space allocation: The ACOC must be such as to be integrated into a nacelle under an aircraft wing (<19 PAX). The space allocation CAD part will be provided during the project by TURBOMECA.
- Objective of mass: the target for the mass will be agreed between TURBOMECA and the partner.
    - The partner will first perform a benchmark to list current ACOC in service together with their aircraft applications and their masses.
    - The partner will also list & classify (based on criteria agreed by TURBOMECA) the current state-of-the-art for ACOC designs & solutions
    - The partner will finally propose solutions to challenge the current state-of-the-art.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 0	*Air Cooling Oil Cooled System – Management and reporting* **Progress Reporting & Reviews:** • Quarterly progress reports in writing shall be provided by the partner, referring to all agreed workpackages, technical achievement, time schedule, potential risks and proposal for risk mitigation. • Monthly coordination meetings shall be conducted via teleconference. • The partner shall support reporting and agreed review meetings with reasonable visibility on its activities and an adequate level of information. • The review meetings shall be held at the topic manager's facility. **General Requirements:** • The partner shall work to a certified standard process	T0 + 36 months
Task 1	*Benchmark on in-service ACOC*	T0 + 6 months
Task 2	*ACOC integration study*	T0 + 12 months
Task 3	*ACOC design & manufacture*	T0 + 24 months
Task 4	*ACOC performance assessment & validation*	T0 + 36 months

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type (*)***	***Due Date***
D1	*3D CAD model of preliminary design*	D	T0 + 1 month
D2	*Integration assessment study – CFD report*	R	T0 + 3 months
D3	*Result of the benchmark on ACOC*	R	T0 + 6 months
D4	*1D AMESIM model*	D	T0 + 12 months
D5	*Hardware Delivery* ACOC System available at TM ground test facility	R	T0 + 24 months
D6	*Final 3D CAD model*	D	T0 + 34 months
D7	*Final report (lessons learned, test results analysis, recommendation for installation, methodology for heat management analysis and simulation)*	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	*ACOC System Preliminary Design Review*	RM	T0 + 6 months
MS 2	*ACOC System Critical Design Review*	RM	T0 + 12 months
MS 3	*ACOC System Review before testing*	RM	T0 + 24 months
MS 4	*ACOC System Technology Readiness Level Review*	RM	T0 + 34 months

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

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

- ✓ Experience in design, manufacturing, testing and certification of aircraft engine mounts is mandatory
- ✓ Experience in elastomeric dampers is mandatory
- ✓ Experience in dynamic and vibration engine complex environment analysis is mandatory
- ✓ Experience in test bench design and modification is mandatory
- ✓ Experience in endurance tests or other relevant tests contributing to risks abatement is mandatory
- ✓ English language is mandatory

VI. Automated full faced measurement of complex geometries

Type of action (RIA or IA)	RIA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP 4		
Indicative Funding Topic Value (in k€)	1200 k€		
Duration of the action (in Months)	24 months	**Indicative Start Date**[47]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-ENG-02-04	**Automated full faced measurement of complex geometries**
Short description (3 lines)	
The task is to develop a multi-sensor system to determine complex notch geometries of aero engine parts. The acquired data shall represent the notch geometry entirely in order to meet drawing requirements of the inspection process. A full faced digitalization is precondition and programming of a software tool is required. It should include an automated feature extraction (shape deviation, displacement), especially the measurement characteristic "surface profile" has to be measured and compared with drawing specifications. Further a software interface has to be programmed which is able to transfer measurement data to standardized analytical software automatically.	

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

1. Background

Parts machined with the broaching process have to be measured to assure their conformity with the drawings. The measurement is executed on coordinate measurement machines (CMM). For parts manufactured in the future the currently used measurement method is not sufficient. A new multi-sensor system is needed in order to determine the characteristic “surface profile” according to the drawing requirements. The multi-sensor systems shall include tactile sensors and optical sensors. It is a system of highly accurate sensors with which all drawing requirements can be verified on the CMM. It is mandatory that the measurement can be done without pre- or post-treatment.

The data generated by the current measuring process needs a lot of manual formatting effort before usage in evaluation. An interface to the analytics software, which is a software that is used by the analytics department at MTU Aero Engines, has to be generated.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
WP 1	**Management** **Organisation:** The partner shall nominate a team dedicated to the project and should inform MTU Aero Engines project manager about the name/names of this key staff. At least the responsibility of the following functions shall be clearly addressed: Program (single point contact with MTU Aero Engines), Techniques & Quality. **Time Schedule & Work package Description:** • The partner is working to the agreed time-schedule & work package description. • Both, the time-schedule and the work package description laid out in this call shall be further detailed as required and agreed at the beginning of the project. **Progress Reporting & Reviews:** • Quarterly progress reports in writing shall be provided by the partner, referring to all agreed work packages, technical achievement, time schedule, potential risks and proposal for risk mitigation. • Regular coordination meetings shall be installed (preferred as telecon). • The partner shall support reporting and agreed review meetings with reasonable visibility on its activities and an adequate level of information. • The review meetings shall be held in MTU Aero Engines facility. **General Requirements:** • The partner shall work to an established standard process.	During the whole Project
WP 2	WP2 CMM sensor system • Verification of ability of the currently applied sensor for the inspection of notches • Testing of this sensor on a pilot part and a pilot machine • Evaluating the capability of the measurement system	T0+2M
WP 3	WP3 Multi-sensor system • Development of a multi-sensor system • Testing of the multi-sensor system • Evaluating the capability of the measurement system • ISO approval	T0+12M

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

WP 4	WP4 Evaluation Software
	• Analysis of the current process
	• Definition of requirements of the software
	• Selection or development of a software which provides the ability to:
	  ○ process all measurement points and generates a record which is appropriate to MTU standard
	  ○ measure the following characteristics: “surface profile”, measurement of radius, centre offset, broaching angle, rectangularity of the notches, all of them conform to drawing requirements.
	• A comprehensible display of evaluation results is required
	• Execution of software training of a pilot team
		T0+15M

WP 5	WP5 Interface to analytics software • Definition of the tools of the analytics software • Definition of the data format of the analytics software • Definition of the coordinate system used in both analytics software and evaluation software • The evaluation software shall be able to provide data in the specified coordinate system • The data transfer from evaluation to analytics software is at least partly automated and lossless • The complete process is tested	T0+15M
WP 6	WP6 Integration of software and hardware • Definition of a multi-sensor system for all applications • A concept for the equipping of the machine is available • A concept for software launch and updates is available • A concept for the multi-sensor system maintenance and repair is available • Standards for calibration and approval are available • Evaluation of the cooperation of CMM, Multi-sensor system, Evaluation Software and Interface to analytics software • ISO approval • Execution of a training for programmer and operators of the CMM	T0+24M

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Report of project management framework	R	T0
D2.1 **D2.2** **D2.3** **D2.4**	Report about testing of the sensor system on a pilot part The software for processing and reporting of the measurement data according to the MTU standard is defined. Interface between evaluation and analytics software is defined Software trainings for the pilot team is finished	R SW R HW	T0+3M
D3.1 **D3.2** **D3.3** **D3.4** **D3.5**	M3.1 Optimized multi-sensor system is available M3.2 Measurement characteristic “surface profile” can be obtained according to the drawings M3.3 Evaluation software is able to give out measurement data in the specified coordinate system M3.4 The data transfer to the analytics software is at least partly automated M3.5 A concept for the multi-sensor system and the equipping is finished	HW SW SW SW R	T0+15M
D4.1 **D4.2** **D4.3** **D4.4** **D4.5** **D4.6** **D4.7** **D4.8** **D4.9** **D4.10**	Testing of the multi-sensor system is finished for one pilot part Multi-sensor system and CMM are approved according to ISO10360 part 8 and 9 Measurement characteristic “surface profile” can be used in serial-production All measurement characteristics of the broached notches can be obtained according to the drawings The complete process from data acquisition for evaluation at the analytics is proven Concept for the multi-sensor system and the equipping is implemented for the lead part. A complete concept for the implementation in the serial production for the relevant parts is finished Standards for calibration and approval are available. A documentation for the monitoring of the measurement system is available and according to the standards. Training of the staff is finished Integration into the MTU systems (e.g. Guardus, Siemens NX) is confirmed	D R SW SW R R R HW R R	T0+24M

Types: R=Report, D-Data, HW=Hardware, SW=Software

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Project management framework is defined		T0
M2	The multi-sensor system is developed and proofed to work as specified		T0 + 3M
M3	The sensor system is optimised		T0 + 15M
M4	The multi-sensor system, the evaluation software and the interface to the analytics software cooperate and their combined function is demonstrated		T0 + 24M

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

Estimated schedule:

	T0	T0+3M	T0+15M	T0+24M
Deliverables 1	■			
Deliverables 2	■	■		
Deliverables 3	■	■	■	
Deliverables 4	■	■	■	■

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

- ✓ Detailed / very good understanding of CMMs
- ✓ Experience with tactile and optical sensors
- ✓ Experience with multi-sensor systems
- ✓ Experience in software programming
- ✓ Possibility to perform the tests with sensors and CMMs
- ✓ Possibility to perform the tests with the software
- ✓ Possibility to perform the test of the complete system

VII. VHBR Engine – Orbiting Journal Bearing Rig Test

Type of action (RIA or IA)	RIA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP 6		
Indicative Funding Topic Value (in k€)	1100 k€		
Duration of the action (in Months)	24 months	**Indicative Start Date**[48]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-ENG-03-09	**VHBR Engine – Orbiting Journal Bearing Rig Test**
Short description (3 lines)	
To design, build and operate a test rig capable of operating a journal bearing in a rotating field under high loads and speeds. The rig should be used to demonstrate the operational boundaries of journal bearings operating in a rotating field and understand the behaviours for consideration when applied to an epicyclic gear box.	

[48] 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 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. An orbiting journal bearing rig will enable understanding of the behaviour of journal bearing operation in a representative PGB environment to validate the bearing design, simulation methods and operational limits. The validation of these methods and limits is required to ensure the bearings can meet life, reliability and certification requirements, enable the optimisation of the journal bearing design, and improve robustness to extreme operating conditions.

The work intended to be covered by the Partner selected will be to design, build and operate an orbiting journal bearing rig capable of representing the operation within a PGB environment. The rig should include sufficient information to understand all aspects of the journal bearing behavior and operation. The rig should be capable of testing a variety of detailed journal bearing design features (*profiling, oil feed, hydraulic dams, etc*).

The successful Partner will demonstrate a proven capability to deliver complex bearing rigs with flow visualisation and precision measurements in arduous environments. The partner must also demonstrate the ability to post process complex test measurements from a variety of measurement techniques to provide rationalised results including uncertainty statements. The journal bearing measurements must include but are not limited to speed, load, alignment, pressure distribution, temperature distribution, operating clearances, film thicknesses, oil distribution, heat generation, flow rates (feed and scavenge), and friction.

2. Scope of work

Tasks		
Ref. No.	***Title – Description***	***Due Date***
WP 1	**Orbiting Journal Bearing Rig - Design**	6 months
WP 2	**Build and Commissioning**	12 months
WP 3	**Test – Endurance and Extreme Conditions**	24 months
WP 4	**Post Process Measurement Data**	24 months

The main objective of this project is to deliver a rig test programme for a journal bearing operating in an environment which is representative of a PGB planet bearing in future large civil geared turbofan aeroengine applications. The use of journal bearing 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 a clear understanding of the journal bearing behaviour and operational limits is required. The results from the rig test will be used to validate design methods to enable optimisation of future engine designs, ensure robustness against extreme operating conditions, and meet life and reliability requirements for aeroengine applications.

Rolls-Royce will provide all test bearing designs, test bearing hardware and rig test requirements. The interfaces between the test bearings and the rig must be agreed between R-R and the successful partner. The successful Partner will be responsible for all other aspects of the rig design, hardware, build, test and post processing of the results.

The orbiting journal bearing rig is primarily to support a Rolls-Royce project within Civil Large Engines but the rig could potentially be utilized for future middle-of-the-market opportunities. The rig design should therefore consider scalability to enable the rig to be used for varying bearing geometries and operating conditions.

To enable the delivery of a successful programme four distinct work packages (WP) have been identified. WP 1 for rig design, WP 2 for rig build and commissioning, WP 3 for test and WP 4 for post processing of the measurement data. The orbiting rig will provide demonstration of a PGB journal bearing design to a maturity level TRL4.

WP 1 – Orbiting Journal Bearing Rig - Design

This work package covers all aspects of design of the orbiting journal bearing rig including measurement techniques and instrumentation. Rolls-Royce will provide all test bearing designs, test bearing hardware and rig test requirements. The interfaces between the test bearings and the rig must be agreed between Rolls-Royce and the successful partner.

WP 2 – Build and Commissioning

This work package covers all aspects of build and commissioning of the orbiting journal bearing rig incorporating the Rolls-Royce test bearings. All instrumentation must be calibrated before and after test to ensure reliable results are produced.

WP 3 – Test

This work package covers all aspects of the rig operation to conduct the test and generate the test data. All test requirements will be defined by Rolls-Royce and agreed with the Partner during the design of the rig. The details of the test (e.g. schedule, operating conditions, durations, alert limits) must be agreed between R-R and the Partner.

The tests have been categorised as Endurance and Extreme Conditions. The tests detailed under Endurance will include but are not limited to Operational Envelope, CF boundary limits, Mixed Friction, and Start-up/Shut-down. The tests detailed under Extreme conditions will include but are not limited to the following: Low Oil, induced damage and damage tolerance.

The measurements and observations from the orbiting journal bearing rig must include but are not limited to flow visualization, film thicknesses, vibration, bearing condition.

WP 4 – Post Process Measurement Data

This work package covers all aspects of post processing of data obtained during the test. The raw data is to be processed to ensure clear results are provided against the defined operating conditions. The post processing techniques are to be agreed with Rolls-Royce. The post processed results must include an uncertainty statement considering all aspects of uncertainty for every measurement technique used on the rig.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
WP 1	Finalise Rig Design	Deliverable	8 months
WP 2	Rig Assembled	Deliverable	13 months
WP 2	Rig Commissioned	Deliverable	14 months
WP 3	All Tests Complete	Deliverable	23 months
WP 4	Post Process Results & Report	Deliverable	24 months

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
WP 1	Preliminary Test Requirements	Report	1 months
WP 1	Preliminary Rig Design Review	Review	3 months
WP 1	Agree Test Bearing Interfaces	Agreement	6 months
WP 1	Agree Test Requirements	Agreement	6 months
WP 1	Critical Rig Design Review	Review	8 months
WP 1	Agree Instrumentation & Measurement Techniques	Agreement	8 months
WP 2	Procure Components	Hardware	8 months
WP 1	Agree Test Conditions	Agreement	10 months
WP 2	Receive Rig Components	Hardware	12 months
WP 2	Rig Assembled	Milestone	13 months
WP 2	Rig Commissioned	Milestone	14 months
WP 3	Endurance Tests Complete	Milestone	18 months
WP 3	Extreme Condition Tests Complete	Milestone	23 months
WP 3	Deliver raw test data and observations	Report	23 months
WP 4	Post Process Results & Report	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 from the candidate and it is therefore expected that the response will address the following areas of expertise as a minimum

Skill 1
Complex bearing rig design including precision measurement, instrumentation and controls.
Skill 2
Quality controlled facilities, processes and environment for rig.
Skill 3
Complex bearing rig assembly, commissioning and operation.
Skill 4
Test data post processing methods. Understanding of measurement uncertainty and how to include all aspects from instrumentation measurements and design limitations.

VIII. Innovations in Titanium investment casting of lightweight structural components for aero engines

Type of action (RIA or IA)	RIA		
Programme Area	Engine ITD		
Joint Technical Programme (JTP) Ref.	WP 6		
Indicative Funding Topic Value (in k€)	800 k€		
Duration of the action (in Months)	36 months	**Indicative Start Date**[49]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-ENG-03-10	**Innovations in Titanium investment casting of lightweight structural components for aero engines**
Short description (3 lines)	
In this Topic the limits of the casting process will be challenged and improvements are sought with regard to geometry limitations impacting weight, quality and cost for jet engine structures. Possibilities in the investment casting process will systematically be identified, explored and eventually verified. Examples of technologies range from pattern making and shell/core technology to non-destructive testing and repair. In addition the castability for a range of titanium alloys will be investigated using Ti 6-4 as the reference alloy. The project consortium is anticipated to propose the content of the research and in interaction with the topic manager select specific geometries, alloys and process steps to work on. A range of component sizes are of interest to explore but typical final component weights may range from 20 kg to 100kg	

[49] 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 performance and architecture, in component design and in the processes and materials that are used to manufacture parts.

The topic manager is developing innovative compressor structure technology for a new Very High Bypass Ratio (VHBR) engine architecture. The technologies will be matured and eventually demonstrated in full scale engine demonstrator tests. The structures will be designed with a geometrically complex shape to incorporate all necessary functionality at the same time as they will be optimized for lowest weight, cost and compressor efficiency. An example of a similar structure from an existing engine can be seen in Fig 1.

The component technology developed by the topic manager is foreseen to be made in titanium alloy(s) using a fabrication approach where several subcomponents in sheet, forged, additively manufactured or cast form are welded together to form the final component geometry. A significant portion of the structure will be made using the investment casting process.

The investment casting process is today the predominant process for making cold engine structures. It has the ability to make complex geometry parts with good quality in a productive way. There are however still opportunities for improvements in the basic process, possibilities for innovation in how to create certain complex geometries and in the selection of titanium alloy(s) to use.

The research will be performed interactively with the Topic manager covering all process steps for a titanium casting – from design, material selection and requirements setting to inspection procedures and repair before shipment. The partner/consortium is expected to provide innovative ideas while the role of the Topic manager will be to guide on design issues and alloy selection, to be involved in decision points where down-selection are made and in the assessment of benefit for the innovations being worked. The final results should result in improved engine performance through higher stiffness, reduced component weight and finally reduced overall cost structure.

Finally, some larger demonstrator components will be cast in the project with geometries from the specific compressor case for the engine demonstrator. Even if there is no guarantee from the Topic manager that the components can be engine tested, this step is seen as critical in maturing the technology to a level (reach TRL 5 or 6) where the next step can be commercialisation. The final cast components will be checked towards drawings and specifications for the compressor case to the engine demo.

2. Scope of work

The work scope can be split into two research strands. The first strand covers innovation in the investment casting process chain and the second strand comprise exploration castability for alternative titanium alloys using Ti 6-4 as the baseline for comparison.

The cost for material will be covered by the partner/consortium while the support from the topic manager will be funded by the Topic manager.

Tasks		
Ref. No.	***Title – Description***	***Due Date***
1	**Management:** **Organisation:** – The partner shall nominate a team dedicated to the project and should inform the Topic manager about the name/names of this key staff. At minimum the responsibility of the following functions shall be clearly addressed: Programme (single point contact with Topic Manager), Engineering & Quality. **Time Schedule & Work package Description:** – The partner shall work to the agreed time-schedule (outlined in Part 3) and work package description. – The time-schedule and the work package description laid out in this Call shall be further detailed as required and agreed during negotiation based on the Partner's proposal. **Progress Reporting & Reviews:** – Monthly one-pager and quarterly progress reports in writing shall be provided by the partner, referring to all agreed work packages, technical achievement, time schedule, potential risks and proposal for risk mitigation. – Regular coordination meetings shall be installed (preferred as telecom). – The partner shall support reporting and agreed review meetings with reasonable visibility on its activities and an adequate level of information. The review meetings shall be held quarterly by WEBEX, at Topic Manager's premises or at the partner's premises.	M36

Tasks		
Ref. No.	***Title – Description***	***Due Date***
2	**Systematic identification of process improvements:** Perform value stream mapping of the investment casting process to identify relevant areas for research and improvements. Perform literature survey to find ideas for process improvements Discuss with Topic manager to identify improvements in the interaction with design. Summarize and select areas for research.	M4
3	**Development and test campaigns with 3- 4 process ideas** Launch development of supporting technologies Perform initial trials on simplified geometries – TRL3 level and select at least two technologies for further maturation Perform second campaign with at least two technologies on more component like geometries (~TRL4) The development and test should be supported with relevant process simulations to ensure that the correct physics is captured and understood.	M24
4	**Explore castability for alternative titanium alloys** The topic manager will propose a number of alternative titanium alloys for which the partner/consortium will perform a quantitative, castability assessment in two steps and compare the results to the baseline alloy Ti 6-4. 1- Through a literature review and analytical assessment 2- By performing trial castings in "component like geometries for Ti6-4 and for at least two alternative alloys. 3- First mechanical property characterization to estimate effect of casting process (thick and thin sections) on mechanical properties. Samples from the casting trials should be sent to the topic manager for further investigation.	M18

Tasks		
Ref. No.	***Title – Description***	***Due Date***
5	**Cast manufacturing demonstrator(s)** Based on results from tasks 2 – 4, a selection of appropriate innovative process steps should be demonstrated in engine relevant component(s) (represented by the compressor case design developed by the topic manager). For costing purposes it is assumed that the manufacturing demonstration activity will make 2 to 8 components with a total weight of approximately 250 kg. An alloy selection based on the results from task 4 will be made between the baseline alloy and the alternatives. Finally a thorough quality control is to be performed on the manufactured component. Dimensional deviations and potential defects should be reported. The components are to be shipped to the topic manager after completed control.	M32
6	**Final assessment** An evaluation of the project will be conducted covering benefits and drawbacks for the engine (Performance, Weight, Cost). The topic manager will help in assessing these aspects.	M36

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D1.1	Project management plan – Detailed schedule, description of team structure and communication with topic manager.	Report	M3
D2.1	Summary of process improvement ideas – Report of idea generation including recommendation of technologies to take further	Report	M4
D3.1	Report on TRL3 process trials	Report	M15
D3.2	Report on TRL4 process trials	Report	M24
D4.1	Report on castability of alternative titanium alloys – including both the literature survey, results from casting trials and basic mechanical property testing.	Report	M18
D5.1	Documentation of full scale casting trials – Including process description and documentation from quality control	Report	M32

D6.1	Final assessment	Report	M36

Milestones (when appropriate)			
M2.1	Down-select of promising process technologies performed.	Coord memo	M4
M3.1	Down-select of technologies after TRL3 trials performed	Coord memo	M14
M4.1	Samples from alternative alloy castings sent to the topic manager	Material and Coord memo	M17
M5.1	Decision on what technologies and alloys to include in the final castings	Coord memo	M22
M5.2	Full scale components sent to the topic manager	Components and coord memo	M32

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

- The CfP partner/consortium should have equipment, or an available supply network for investment casting of titanium alloy components with a final component weight between 20 and 100kg.
- The partner/consortium should preferably be certified for delivering parts to the aerospace industry (AS9100)
- The CfP partner/consortium should have equipment, or an available supply network, for manufacturing of Hot Isostatic Pressing (HIP).
- The CfP partner/consortium should have ability and experience in manufacturing process simulation (mainly investment casting)
- The CfP partner/consortium needs testing and analysis equipment for evaluating the results from casting trials (non-destructive inspection methods, metallographic equipment and basic mechanical testing), or an available supply network that can perform these trials. These tests should be performed to appropriate aerospace standards.
- The CfP partner/consortium should have experience in titanium alloy material science to be able to assess the alternative alloys.
- Experience in performing applied collaborative industrial research in international environment is considered as essential.

IX. Aerodynamic rigs for VHBR IP Turbine

Type of action (RIA or IA)	IA		
Programme Area	Engine ITD		
Joint Technical Programme (JTP) Ref.	WP 5.2		
Indicative Funding Topic Value (in k€)	2500 k€		
Duration of the action (in Months)	24 months	**Indicative Start Date**[50]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-ENG-03-11	**Aerodynamic rigs for VHBR IP Turbine**
Short description (3 lines)	
The work will comprise the aerodynamic rig testing associated to the WP5.2 needed to allow ITP to develop validated technology 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, rig testing and supply of all test data.	

[50] 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.

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.

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 four (4) aerodynamic rigs (test vehicles).
Three of them will be 1 ½ stages rigs to study in detail aerofoil improved losses and the noise generated. The fourth rig will be a redesign of one of the rigs developed in the ITP Core Partner scope of work(VT3)to study advanced Vane 1 concepts.
The three first rigs will have a stator-rotor-stator (or OGV) configuration and will be named as follows:

- VT4-1 to study in detail 2D and 3D losses of airfoils representatives of the last stages of VHBR IP Turbine.
- VT4-2 to study in detail OGV losses representative of VHBR IP Turbine.
- VT4-3 to study 3D optimised vanes, clocking and other acoustic technologies for noise reduction.

The three rigs will share the same general arrangement and most of the casings and rings will be common. Also stator 1 will be the same for the three rigs, that can actually be considered as three different builds of a unique rig. VT4-2 and VT4-3 will require a new rotor as the inlet conditions of OGV in VT4-2 and noise optimised NGV in VT4-3 will be different to VT4-1. Details of each of the rigs are explained next. Figure 1 shows a schematic of the VT4 configuration.

Squematic of VT4 configuration

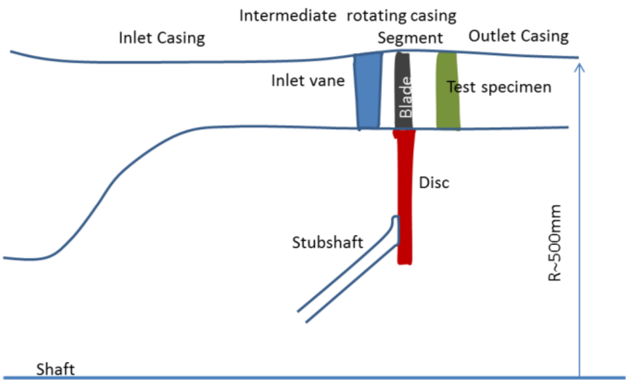


Figure 1.

These three 1 ½ rigs will be complementary to the rigs defined in ITP Core Partner scope of Work JTI-CS2-2014-CPW01-ENG-03-01. Because of the larger size as well as the rig construction, detailed measurements will be taken that will allow a deep understanding of the flow physics.
In addition, three reference rig tests should also be included in the scope of work. The necessity of these reference tests will be explained later.

<u>Task 1:</u> 1 ½ stages rig VT4-1

As commented before, VT4-1 rig will have a stator-rotor-stator configuration. Geometry of the rows will be representative of the rear stages of VHPR IP Turbines. Within the scope of the work is the detailed mechanical 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. The following requirements should be met:

- Manufacturing quality should be according to ITP standards. (e.g. Airfoil profile tolerance 0,10 mm, wetted surfaces roughness 0,8 µm,…).
- Stator 1 mounting system should allow the possibility to change clocking position between statort 1 and stator 2. This should be done without opening the rig to reduce as much as possible measurements uncertainties between subsequent tests.
- 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 VT4-1.
- Outer casings should allow at least +25 degrees traversing capabilities upstream of stator 1, between stator 1 and rotor, between rotor and stator 2 and in two stations dowstream of stator 2, one located one chord downstream and another one located at least ten chords downstream. At all these traversing planes, measurements with minituarised five-hole probes and hot wire probes should be taken.
- Total pressure and total temperature rakes should be placed upstream of stator 1 and downstream of stator 2 (in the measurement location far downstream).
- Inlet boundary layer should be traversed at inlet plane with miniaturised boundary layer probes or any non-intrusive measurement system.
- All the instrumentation to be used should be statically and dynamically calibrated in an environment representative of the test conditions.
- Tip clearance probes should be placed in the outer casing to measure rotor tip clearance in all test conditions.
- Stator 2 surface should be instrumented with static pressure tappings at pressure and suction surfaces in five span locations. As a reference, 16 tappings at suction side and 9 at pressure side will be required. Instrumentation has to be non-intrusive, tubes must be routed through the aerofoil and surface reconstructed to design intent wetted surface.
- Stator 2 surface should also be instrumented with hot film gauges at midspan section.
- The rig should have provision for simulating purge flows.
- Test matrix will cover VHBR IP Turbine representative operating conditions, therefore a facility that allows for altitude conditions is required. In particular the test matrix should include sensitity to Reynolds number to cover the expected Reynolds number range in engine applications from 25 klbf thrust to 110 klbf. Also, sensitivity to Mach number and incidence including very high negative incidence typical of overspeed region should be included in the test matrix. As a reference, test matrix should cover a range of Reynolds number in stator 2 based on exit velocity and suction perimeter from 50,000 to 250,000. The range in exit Mach number in stator 2 should go from 0.6 to 1.0. Finally the range of incidences at stator 2 inlet should cover a range from -70 degrees to +30 degrees.
- Noise measurements should be taken in operating conditions representative of noise points of VHBR IP

Turbine.

- Test matrix should also include sensitivity of aerodynamic and noise performance to clocking position between stator 1 and stator 2.
- The main objective of the rig is to have detailed measurements in order to characterize aerodynamic and noise performance of all the rows. In particular, it is key to measure with accuracy row losses, less than 0.5%.

Task 2: 1 ½ stages rig VT4-2

VT4-2 rig will be a redesign of VT-1 in which the stator 2 will be replaced with an OGV representative of VHBR IP Turbine. Rotor blade will also need to be redesigned in order to have the right velocity triangles in the OGV. Stator 1 will remain the same as VT4-1. As in VT4-1, 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. The following requirements should be met:

- Manufacturing quality should be according to ITP standard. (e.g. Airfoil profile tolerance 0,10 mm, wetted surfaces roughness 0,8 µm,…).
- 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 VT4-1.
- Outer casings should allow +25 degrees traversing capabilities upstream of stator 1, between stator 1 and rotor and between rotor and OGV. OGV exit flow will be traversed by means of the NMM as described before. 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.
- Inlet total pressure and total temperature rakes as well as boundary layer probes described for VT4-1 should also be used in VT4-2.
- OGV surface should be instrumented with static pressure tappings at pressure and suction surfaces in three span locations. As a reference, 16 tappings at suction side and 9 at pressure side will be required. Instrumentation has to be non-intrusive, tubes must be routed through the aerofoil and surface reconstructed to design intent wetted surface.
- OGV surface should also be instrumented with hot film gauges at midspan section.
- All the instrumentation to be used should be statically and dynamically calibrated in an environment representative of the test conditions.
- Tip clearance probes should be placed in the outer casing to measure rotor tip clearance in all test conditions.
- As in VT4-1, test matrix will cover VHBR IP Turbine representative operating conditions, therefore a facility that allows for altitude conditions is required. In particular the test matrix should include sensitity to Reynolds number to cover the expected Reynolds number range in engine applications from 25 klbf thrust to 110 klbf. Also, sensitivity to Mach number and incidence including very high negative incidence typical of overspeed region should be included in the test matrix.

- Noise measurements should be taken in operating conditions representative of noise points of VHPR IP Turbine.

<u>Task 3:</u> 1 ½ stages rig VT4-3

Rig VT4-3 will be a redesign of VT4-1 in which a new stator 2 with 3D optimised gometry for noise reduction will be tested. A new rotor will also be needed because of the effect of the re-design stator 2 in rotor performance. Stator 1 will remain the same as VT4-1 and VT4-2. As in previous builds, 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. Instrumentation requirements, test matrix and measurements should be the same as VT4-1. Also, for a good back to back comparison, it will be desirable to use the same instrumentation (probes, rakes) as in VT4-1.

<u>Task 4:</u> Rig VT3-2

As commented before, the fourth rig will be a redesign of VT3 to study advanced Vane 1 concepts. It is already know that in VHBR IP turbines the vane 1 has an enormous effect on aerodynamic and noise. Therefore, there is a great opportunity of improvement of the turbine by means of introducing new design solutions in Vane 1. Some promising configurations have been already indentified (i.e. Splitter Vane) but many others will be studied within WP5.2. A trade off study, considering aerodynamic impact, noise, forced response, weight, cost and manufacturing issues will be done and the resulting optimum configuration will be tested in VT3-2. The purpose of VT3-2 will be to probe experimentally the aerodynamic and noise benefit of the alternative configuration of vane 1. It will be a redesign of VT3 to allow for back to back comparison.
Figure 2 shows a schematic of VT3.

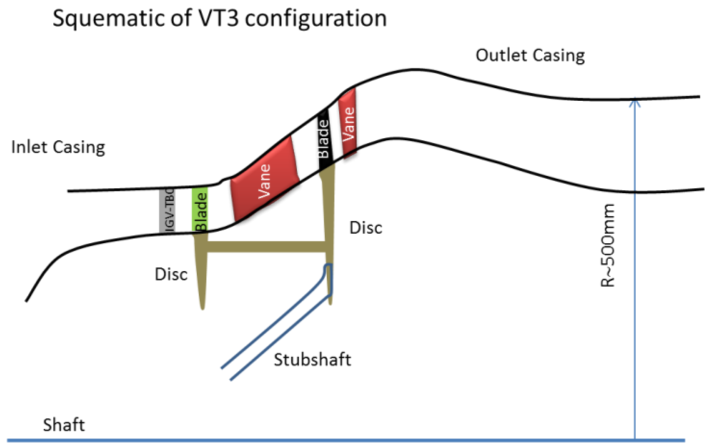


Figure 2.

As in VT4 rigs, 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. The following requirements should be met:

- Manufacturing quality should be according to ITP standard. (e.g. Airfoil profile tolerance 0,10 mm, wetted surfaces roughness 0,8 µm,…).
- VT3 rig configuration consists on a first row of rotors followed by a vane 1, rotor 1 and vane 2 representative of VHBR IP turbine. The intention of the first row of rotors is to leave conditions similar to those found at the inlet of VHBR IP Turbines. The design shall allow for an IGV upstream of the first rotor in order to produce the right inlet swirl to the rotor; it will be decided during detailed design.
- In VT3-2 rig, a new vane 1 geometry will be introduced. Also, rotor 1 and vane 2 will also be redesigned to adapt to the new flow conditions leaving Vane 1. Upstream rotor and IGV will remain unchanged.
- VT3-2 should have the same instrumentation as VT3. This will consist in:
    - At least 25 degrees area traverse measuring between IGV and first rotor, between rotor and vane 1, between vane 1 and rotor 1, between rotor 1 and vane 2 and in two locations downstream of vane 2, the first one chord downstream and another one at least five chords downstream. 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 inlet and exit planes, area traverse with temperature probes should also be done.
    - Total pressure and total temperature between rotor 1 and vane 1 and downstream of vane 2, in the location at least five chord downstream.
    - Static pressure tappings in suction and pressure sides of vane 1 and vane 2 at five span locations (2%, 30%, 50%, 70% and 98%). Also, hotfilm gauges should be placed at midspan section of vane 1 and vane 2. 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.
    - Noise measurements should be taken with the Noise Measurement Module (NMM) described before.
    - All the instrumentation to be used should be statically and dynamically calibrated in an environment representative of the test conditions.
- VT3-2 should have capability to simulate and modify purge flows.
- Test matrix of VT3-2 should be the same as the one performed in ITP for VT3. It will include the following test conditions:
    - Sensitivity to Reynolds number.
    - Turbine map characterization, covering a range of conditions representative of VHBR IP Turbine.
    - Sensitivity to purge flows.
    - Noise measurements should be taken in operating conditions representative of noise points of VHBR IP Turbine.

<u>Task 5:</u> Testing of reference rigs

The main objective of the rig testing described in tasks 1 to 4, is to characterize the new aerodynamic and acoustic technologies that will be introduced in the different rigs. In particular, it is key to assess the benefit in row losses/rig efficiency and IP Turbine noise of these technologies. As a consequence, is mandatory to compare the results of each rig with a reference rig tested in the same facility with the same instrumentation. This is because it is already know 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 of each technology.

The reference for each rig is dependent on the technologies to be introduced and is described below:

- **VT4-1**. The objective of this rig is to characterize aerodynamic losses 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. It is also important for ITP to compare measured losses of VT4-1 with existing data in ITP of row losses of LP Turbines. Therefore, the reference rig for VT4-1 should be a rig representative of the LP Turbine designed by ITP for state of the art turbofans. This way, a back to back comparison between aerodynamic technology of VHBR IP turbine to be developed in WP 5.2 and former LP Turbine technology could be done, which 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.
- **VT4-2**. For the same reasons already commented for VT4-1, the reference rig for VT4-2 should be a similar OGV test rig representative of the LP Turbine designed by ITP for state of the art turbofans. 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.
- **VT4-3**. Reference rig for VT4-3 will be VT4-1 rig. So, any extra test will be required.
- **VT3-2**. As described above, the main objective of VT3-2 is to experimentally prove the benefits in aerodynamic and noise of the alternative Vane 1 configuration. This will be done by comparison with VT3 results. Therefore, for a proper back to back comparison and in order to reduce uncertainties as much as possible, both rigs should be measured in the same facility with the same instrumentation. So, the reference rig for VT3-2 will be VT3, to be designed, manufactured and tested by ITP. Therefore, ITP will provide VT3 geometry. The hardware required to adapt VT3 to the facility will be the same as for VT3-2, so no extra hardware will be required. However, testing of VT3 should be within the scope of the work

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T1	Design, manufacturing and testing of VT4-1 rig	M0-M12
T2	Design, manufacturing and testing of VT4-2 rig	M3-M15
T3	Design, manufacturing and testing of VT4-3 rig	M6-M18
T4	Design, manufacturing and testing of VT3-2 rig	M9-M24
T5	Testing of reference rigs	M0-M20

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D1.1	VT4-1 rig part drawings	Drawings	M4
D1.2	VT4-1 test schedule	Report	M6
D1.3	VT4-1 calibration report	Report	M6
D1.4	VT4-1 test report	Report	M10
D2.1	VT4-2 rig part drawings	Drawings	M8
D2.2	VT4-2 test schedule	Report	M9
D2.3	VT4-2 calibration report	Report	M9
D2.4	VT4-2 test report	Report	M13
D3.1	VT4-3 rig part drawings	Drawings	M12
D3.2	VT4-3 test schedule	Report	M14
D3.3	VT4-3 calibration report	Report	M14
D3.4	VT4-3 test report	Report	M16
D4.1	VT3-2 rig part drawings	Drawings	M15
D4.2	VT3-2 test schedule	Report	M18
D4.3	VT3-2 calibration report	Report	M18
D4.4	VT3-2 test report	Report	M24
D5.1	Reference tests report	Report	M20

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M1.1	All VT4-1 parts available at facility		M5
M1.2	VT4-1 Test Readiness Review		M6
M1.3	Pass to test of VT4-1		M6
M1.4	End of test of VT4-1		M9
M1.5	VT4-1 Post Test Review		M10
M2.1	All VT4-2 parts available at facility		M8
M2.2	VT4-2 Test Readiness Review		M9
M2.3	Pass to test of VT4-2		M10
M2.4	End of test of VT4-2		M12
M2.5	VT4-2 Post Test Review		M13

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M3.1	All VT4-3 parts available at facility		M12
M3.2	VT4-3 Test Readiness Review		M13
M3.3	Pass to test of VT4-3		M14
M3.4	End of test of VT4-3		M15
M3.5	VT4-3 Post Test Review		M16
M4.1	All VT3-2 parts available at facility		M15
M4.2	VT3-2 Test Readiness Review		M16
M4.3	Pass to test of VT3-2		M18
M4.4	End of test of VT3-2		M21
M4.5	VT3-2 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: 7.500 RPM.
  - Mass flow: 18 Kg/s.
  - Pressure ratio: 5.
  - 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.

Test facilities have to be already commissioned and general description has to be presented by Applicant when replying to this Call.
Proven experience and capability of the test facility to adjust operating conditions with a high level of stability and repeatability are required.
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, In particular, previous experience in testing sensitivity to clocking position between stators, is highly appreciated.
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.

X. Development of intelligent oil system enablers for large VHBR engine oil lubrication and heat management systems.

Type of action (RIA or IA)	RIA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP 6		
Indicative Funding Topic Value (in k€)	3000 k€		
Duration of the action (in Months)	40 months	Indicative Start Date[51]	Q1 2017

Identification	Title
JTI-CS2-2016-CFP03-ENG-03-12	**Development of intelligent oil system enablers for large VHBR engine oil lubrication and heat management systems**
Short description (3 lines)	
The current proposal is aimed at understanding & developing key technology items critical to the successful realisation of oil lubrication and heat management systems for future large geared gas turbine engines. This proposal will evolve the TRL of these key technology items for the large engine market VHBR engine demonstrator in WP6 of Engine ITD.	

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

1. Background

As a part of the engine projects in Clean Sky 2, the topic manager will lead the design and development of VHBR technologies for the VHBR engine demonstrator (WP6 of Engine ITD) for the large engine market. One of the key technologies developed to meet the goals of WP6 is an efficient, mass optimised oil lubrication and heat management system.

Future VHBR engines represent a significant challenge for Oil Heat Management System (OHMS) designs due to significantly increased heat loads, the attendant increase in system oil volumes that come with these heat loads, and a need for more complex control schemes to ensure optimum system performance including off-design conditions.

In order to ensure that the benefits of future VHBR products are fully realised, then these future oil systems are required to be mass optimised to ensure that the increase in system volume does not penalise fuel burn, are more efficient to ensure optimum cycle performance, and are more intelligent to ensure that oil and heat flows are managed across the engine operating range.

The current understanding held by the topic manager is built upon current civil large engine (CLE) best practice and has the following shortcomings with regard to VHBR products:

1) System architecture: CLE VHBR products may have their oil system architectures configured in a variety of schemes; single, dual or separate systems compared to current CLE products that use simple single system architectures.
2) Heat rejection and system flow complexity: a CLE VHBR will require a significant increase in both system flows and heat rejection system capacity compared to the current CLE products. If not intelligently applied, this increase in system capacity will erode the performance benefits gained by the VHBR architecture.
3) Control schemes: it is also likely that future VHBR OHMS systems will require more complex control systems to match performance with operating condition and to cope with the transient needs of the product and off-design conditions where oil flows may be critical.

The current proposal is expected to deliver higher TRL level understanding of the key technologies required to deliver a large volume oil system for VHBR engines.

The objectives of the current proposal are to:

I. Develop a model based systems engineering (MBSE) tool to aid the evaluation and selection of candidate VHBR system architectures.
II. Develop methods and techniques required to achieve variable flows that will allow oil feed and scavenge systems to be optimised around the flight envelope.
III. Demonstrate a variable flow intelligent oil system and advanced control scheme and show how operation can be optimised across a range of simulated flight conditions.
IV. Research into autonomous fault detection and correction for future Oil Systems.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T1	Management	T0 + 12 months
T2	Model based Systems Engineering architecture study	T0 + 6 months
T3	Benefits of variable flow control	T0 + 12 months
T4	Variable flow oil pumping & scavenging	T0 + 24 months
T5	Demonstrate Intelligent oil system flow control	T0 + 36 months
T6	Autonomous monitoring and fault correction	T0 + 38 months

A brief description of the tasks is given below:

Task 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:

- 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 summarised.
- Regular coordination meetings shall be conducted via telecom or webex where appropriate.
- The partners shall support reporting and review meetings with reasonable visibility on the activities and an adequate level of information.
- The partners shall support quarterly face-to-face review meetings to discuss the progress.

Task-2: Model based Systems Engineering architecture study

This task is a development of a model based systems engineering approach to architecture optimisation. For any given duty, a wide range of oil and heat management system (OHMS) architectures can be conceived, with varying degrees of effectiveness, complexity, cost and weight. The challenge of selecting an optimum architecture is significantly greater in engines such as Ultrafan^{TM} where power is transmitted through a reduction gearbox. This study would develop a model based systems engineering (MBSE) approach to down-selecting a small number of architectures from a large number of candidates, based on alignment with requirements.

The task will build upon a preliminary investigation already performed by the topic manager into the use of model based systems engineering tools.

Task-3: Benefits of variable flow control

Today's oil systems typically adopt pumps mechanically driven from the engine HP spool. The pump is sized to a 'worst case' operating condition, but will then over-supply at other operating conditions, resulting in unnecessary heat-to-oil in the bearing chambers. In addition independent control of the scavenging system may be required to ensure the large oil flows inherent within future VHBR products are managed at off-design conditions.

This task shall quantify the benefits of variable flow oil systems for both feed and scavenge systems considering impacts to product efficiency as well as benefits to off-design engine handling (incl sealing and venting system performance) and transients.

Task 4: Variable flow oil pumping and scavenging

This task should focus on methods for incorporating variable flow methods and devices into VHBR oil systems that will allow oil feed and scavenge to be optimised throughout the flight cycle. Methods of achieving this variability may include, but not be limited to; mechanical, electro-mechanical, or electric driven feed and scavenge system and control system designs. Opportunities for improving oil management on start-up and shut-down will also be explored.

An additional element of this task is to study schemes for de-coupling feed from scavenge pumping in order that independent scheduling or control is enabled.

Task-5: Demonstration of Intelligent oil system with flow control

Using the findings of tasks 2, 3 and 4 a representative oil system test rig shall be created and used to demonstrate an oil system that is intelligently controlled and that varies system conditions in response to system measurements made. The demonstration shall include a simulation of an oil system incorporating at least (but not limited to) an oil tank, oil pumps, simulated heat loads, simulated heat exchange systems, and simulated engine bearing chambers. The demonstration shall show optimized oil flows across a range of simulated flight conditions and shall demonstrate how start-up and shutdown transients may be better handled by a variable flow system.

The test rig shall also be used to demonstrate how an autonomous sensor and control suite as defined in task 6 may be employed to address system faults that may be simulated.

Task-6: Autonomous monitoring and fault correction

The Ultrafan™ oil and heat management system will require a degree of fault detection and autonomous correction that significantly exceeds anything previously attempted. This task will develop a tool for identifying the optimum sensor suite necessary to uniquely identify OHMS faults. Algorithms will be developed capable of deciding how best to manage any given fault, for example by automatically re-configuring the system by switching valves, diverting heat exchangers etc. These tools will then be demonstrated to TRL5 using the rig described in task 4.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	**Title - Description**	**Type**	**Due Date**
D1	Management report: summarise the project management of the programme, including deliverables, level of spend and dissemination	Report	T0 + 40 months
D2	MBSE Oil System architecture selection tool: report summarizing use of MBSE to down-select from a range of candidate architectures using a requirements focused approach	Report	T0 + 8 months
D3	Benefits of variable flow control: report summarizing benefits of variable flow and control schemes	Report	T0 + 14 months
D4	Variable flow oil pumping: report summarizing design solutions and chosen preferred concept	Report	T0 + 26 months
D5	Demonstration of Intelligent oil system: Report summarizing results from rig test programme	Report / Rig	T0 + 38 months
D6	Autonomous monitoring and fault correction: report summarizing solution for autonomous control system and testing results from rig test programme	Report	T0 + 40 months

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 + 40 months
M2	Variable flow oil pumping: report summarizing design solutions and chosen Preferred concept	Report	T0 + 26 months
M3	Demonstration of Intelligent oil system: report summarizing solution for autonomous control system and testing results from rig test programme	Report	T0 + 40 months

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 the use of Systems Engineering tools and concepts
- ✓ Experience in control system design
- ✓ Ability to simulate Oil System components using theoretical tools
- ✓ Ability to create a complex Oil system based test rig
- ✓ Ability to integrate physical test units, instrumentation, and control system sensors

6. Clean Sky 2 – Systems ITD

I. Mems Accelerometer – Maturity Assessment And Improvement

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP1		
Indicative Funding Topic Value (in k€)	1100 k€		
Duration of the action (in Months)	24 months	**Indicative Start Date**[52]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-SYS-01-02	**Mems Accelerometer– Maturity Assessment And Improvement**
Short description (3 lines)	
In the context of the IMU product development (Cleansky project Modular Advanced Inertial System), the introduction of Silicon Very High Performances MEMS Accelerometers Technology is targeted. The purpose of this call is to define and improve MEMS Accelerometer manufacturing process maturity to reach a minimum MRL and TRL of 5. Once these maturity levels achieved, integration of the MEMS Accelerometer on the IMU will be possible.	

[52] 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 INS.

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 [53] 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).

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 monocristalline 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 widthstand high shock level up to 1000g
- Reliability must be demonstrated under up to 4000 thermal cycles (-40/+95°C)

[53] 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 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 Topic Manager for validation in relevant environment (TRL5)	M24

WP1 : Definition of the target MEMS process

The objectives of this work package are to define a manufacturing process compatible with Topic Managers design and 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 that already demonstrated positive field return in order to be able to implement the MEMS manufacturing process within the planning of this project.

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 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.

WP3 : Manufacturing of 20 MEMS Accelerometers for evaluation by Topic Manager

The objective of this work package is to manufacture, test and deliver 20 MEMS Accelerometers (sensing element + package) for evaluation by Topic Manager.
The evaluation by Topic Manager will lead to a conformity matrix and a list of recommendations to reach the TRL level of 5.

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.

WP5 : Sensors Evaluation : Manufacturing of 40 MEMS cells for evaluation by Topic Manager

The objective of this work package is to manufacture, test and deliver 40 MEMS Accelerometers (sensing element + package) for evaluation by Topic Manager.
The evaluation by 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
D3.2	Evaluation report with Compliance Matrix	Report	M14
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 Topic Manager	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	M12
M5.1	Evaluation report update with Compliance Matrix	Topic Manager Input	M24

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

- ✓ The applicant has to provide evidence of industrial experience in Silicon On Insulator (SOI) MEMS manufacturing.
- ✓ The applicant has to provide evidence of industrial experience in manufacturing long term stable MEMS ceramic packaging under vacuum below 10^{-3}mbar (lifetime > 30 years).
- ✓ The applicant should have the capability to perform physical and functional tests of the device during front-end and back-end processes.- The applicant must provide evidence of experience in high accuracy notch free Deep Reactive Ion Etching (DRIE) (< 0.2 µm accuracy and better than 30 nm etching uniformity on a 6-sigma approach) on thick SOI with its own production equipment.
- ✓ The applicant must have knowledge in the manufacturing and testing of high Q factor resonant MEMS Accelerometers.

II. Development of electromechanical actuators and electronic control units for flight control systems

Type of action (RIA or IA)	RIA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP3		
Indicative Funding Topic Value (in k€)	1600 k€		
Duration of the action (in Months)	24 months	Indicative Start Date[54]	Q1 2017

Identification	Title
JTI-CS2-2016-CFP03-SYS-02-14	**Development of electromechanical actuators and electronic control units for flight control systems**
Short description (3 lines)	
This call covers the development, manufacturing and validation of Electro-Mechanical Actuators (EMA) and associated electronics for Flight Control Systems to be integrated into FTB2 Regional Aircraft IADP. All equipment within this call will be designed and validated with the main objective of being compliant with aerospace certifiable requirements, since the intention is to obtain clearance for flight.	

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

1. Background

Main Characteristics of EMAs to be developed are indicated in the following table:

FCS	CONTROL ALGORITHMS	LOOP OUTPUT SIGNALS	ARQUITECTURE	SENSOR FEEDBACK
EMA AILERON	* Position(*) * Torque (**) * Speed (**)	* Position * Torque * Speed * Current consumption	* BLDC motor * 270VDC * Integrated fail safe brake	*Resolver *LVDT x2 *Temperature *Strain gages
EMA SPOILER	* Position(*) * Torque (**) * Speed (**)	* Position * Torque * Speed * Current consumption	* BLDC motor * 270VDC * Integrated fail safe brake	*Resolver *LVDT x2 *Temperature *Strain gages
EMA FLAP TAB	* Position(*) * Torque (**) * Speed (**)	* Position * Current consumption	* BLDC motor * 28 VDC * Integrated fail safe brake * Rotary actuator * Integrated electronics	*Resolver *RVDTs *Temperature
EMA WINGLET TAB	* Position(*) * Torque (**) * Speed (**)	* Position * Current consumption	* BLDC motor * 28 VDC * Integrated fail safe brake * Rotary actuator * Integrated electronics	*Resolver *RVDTs *Temperature

Table 9:**Main Characteristics of the EMAto be developed**

DEVELOPMENT OF OPTIMIZED AND HIGHLY INTEGRATED MOTORS AND BALL SCREWS FOR THE EMAS (AILERON AND SPOILER).

Based on the requirements defined by the topic manager, the objective is to design, manufacture, test and qualify the motors and ball-screws for an Electromechanical Actuator (EMA) intended for flight control systems (Ailerons & Spoilers). Main technological challenges in the development are reliability, low weight, performance optimization and full compliance with aerospace certifiable requirements since the intention is to obtain a permit to fly for the EMAs.

Motor and ballscrew design shall be common for both aileron and spoiler applications.

MOTOR PRELIMINARY REQUIREMENTS

The motor shall comply with the following requirements:

- Performance required:
  - Stall operation for one minute: 18 Nm
  - Discontinuous operation: maximum operating performances for some cycles:
    - 14 Nm @ 1400 rpm
    - 6 Nm @ 1600 rpm
  - Continuous operating: 3 Nm @ 1300 rpm
  - No load speed: 1900 rpm
  - Voltage supply: 270 VDC.

  - A useful life of 25.000 operating hours shall be demonstrated by analysis/tests.
  - Duty cycle is defined as 3 hours continuous operation and 1 hour stop

- Design and Architecture requirements:
  - Permanent magnet AC motor with wye connection. Motor is composed by two parts:
    - A slotted stator for a three phase winding distribution for achieving a sinusoidal back EMF
    - A passive rotor for permanent magnets housing.

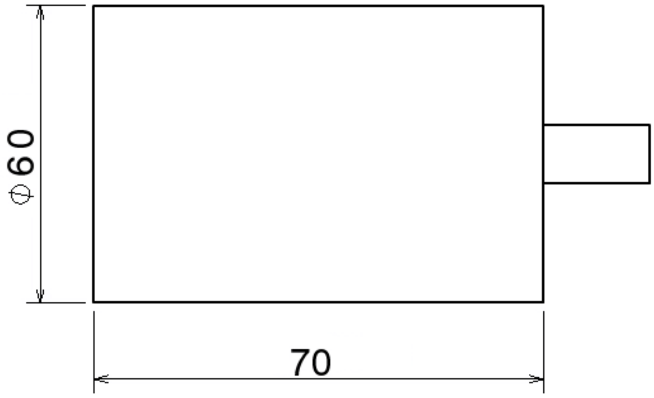
  - A fractional number of motor slots per pole to be agreed jointly with the supplier.

  - Material for the following motor components:
    - Stator with odd slot counts and laminations.
    - High Density Copper Windings
    - Skewed Magnets: Cobalt-Samarium

  - Following constraints are defined for temperature motor sizing, both, the ambient temperature and the heat flow from the electric motor:
    - The motor shall be self-cooled.
    - Maximum operating temperature is 100ºC.
    - Maximum external environmental temperature is 70ºC.
    - Minimum resistance as possible in order to minimize the power dissipation during the continuous operation under 3 Nm. Objective for power dissipation shall be lower than 30 W.

  - The motor shall integrate the necessary sensors for rotor position feedback (resolver/hall sensors) and two PT100 sensors embedded into the stator windings for temperature feedback.

- Space envelope and mass requirements:
  - Maximum allowed mass is 1 Kg.
  - The motor maximum diameter is 60mm and its maximum lenght is 70mm:



- Qualification requirements

The minimum qualification requested will be the necessary to ensure the safety of flight condition and will be agreed with the partner. As a reference, next tables summarises general requirement for the ballscrew design.

Tasks		
	Test Document Reference	***Category: Equipment in wing/fuselage fairing***
Endurance	(*)	
Fatigue	(*)	
Performances	(*)	
Temperature Altitude	RTCA-DO160 D Section 4	C2
Temperature variation	RTCA-DO160 D Section 5	A
Humidity	RTCA-DO160 D Section 6	C
Operational Shock and Crash Safety	RTCA-DO160 G Section 7	B
Vibration	MIL-STD-810F	(*)
Explosion proofness	RTCA-DO160 D Section 9	Environment II
Waterproofness	RTCA-DO160 D Section 10	R
Fluids Susceptibility	RTCA-DO160 D Section 11	F
Sand & Dust	RTCA-DO160 D Section 12	D
Fungus Resistance	RTCA-DO160 D Section 13	F

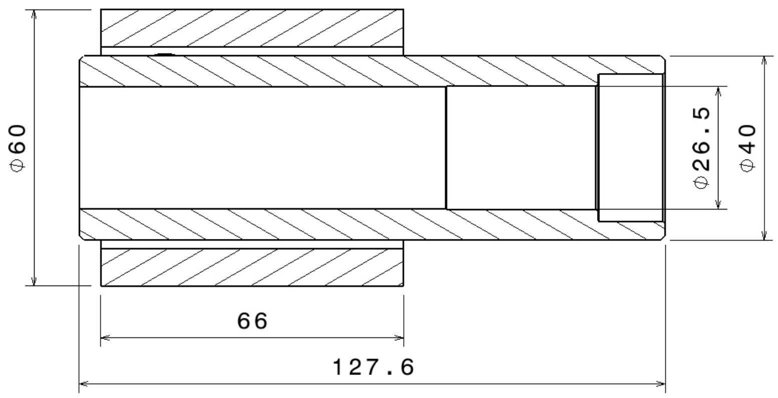
Tasks		
	Test Document Reference	***Category: Equipment in wing/fuselage fairing***
Salt spray	RTCA-DO160 D Section 14	S
Icing	RTCA-DO160 D Section 24	B
Magnetic Effect	RTCA-DO160 G Section 15	Z
Electrostatic discharge	RTCA-DO160 G Section 25	A

(*) Customized profiles will be delivered for this purpose

BALLSCREW PRELIMINARY REQUIREMENTS

- Performance and design requirements
  - Ballscrew pitch: 6 mm.
  - Maximum operational load of 32 kN.
  - A useful life of 25.000 operating hours shall be demonstrated by analysis/tests.

- Space envelope and mass requirements:
  - Maximum mass allowed is 1 kg
  - Preliminary dimensions of the ballscrew and ballnut are shown below:



- Qualification requirements

The minimum qualification requested will be the necessary to ensure the safety of flight condition and will be agreed with the partner. As a reference, next tables summarises general requirement for the ballscrew design.

Tasks		
	Test Document Reference	***Category: Equipment in wing/fuselage fairing***

Tasks		
	Test Document Reference	***Category: Equipment in wing/fuselage fairing***
Endurance	(*)	
Fatigue	(*)	
Performances	(*)	
Temperature Altitude	RTCA-DO160 D Section 4	C2
Temperature variation	RTCA-DO160 D Section 5	A
Humidity	RTCA-DO160 D Section 6	C
Operational Shock and Crash Safety	RTCA-DO160 G Section 7	B
Vibration	MIL-STD-810F	(*)
Explosion proofness	RTCA-DO160 D Section 9	Environment II
Waterproofness	RTCA-DO160 D Section 10	R
Fluids Susceptibility	RTCA-DO160 D Section 11	F
Sand & Dust	RTCA-DO160 D Section 12	D
Fungus Resistance	RTCA-DO160 D Section 13	F
Salt spray	RTCA-DO160 D Section 14	S
Icing	RTCA-DO160 D Section 24	B
Magnetic Effect	RTCA-DO160 G Section 15	Z
Electrostatic discharge	RTCA-DO160 G Section 25	A

(*) Customized profiles will be delivered for this purpose

For all types of actuator a number of units will be manufactured for rig, qualification, A/C integration and spare , as per table below

Rig	Qualification	Total Units
2	3	5
4	3	7

DESIGN, MANUFACTURING AND VALIDATION OF ELECTRONIC CONTROL UNITS (ECU) FOR EMAS TO BE USED IN AILERONS AND SPOILERS OF FTBS IN THE REGIONAL AIRCRAFT.

Based on the conceptual design proposed by the Topic Manager, the work will cover the detailed design and manufacturing of electronic control units for 2 types of electromechanical actuators. For RA-IADP (FTB2) and based on the development Plan for the integration of EMA in Spoilers and Aileron, the development of optimized ECU with high reliability is critical. Main characteristics of both EMAs are summarized in the table below.

AILERON AND SPOILER ELECTRONIC CONTROL UNIT PRELIMINARY REQUIREMENTS

The Electromechanical actuators for aileron and spoiler shall be position controlled. The ECU will be responsible of the implementation of the speed comand received externally. It shall determine the torque and power level to ensure the proper requested speed is achieved.

Fail safe brake shall be temporary deactivate as long as a specific dedicated command signal is received from the A/C.

For integration purposes, at least these interfaces will be considered for the control of ailerons and spoilers:

- Digital buses for internal communication between ECU channels (Control/Monitor)
- Digital CAN bus (x2) and for external communication
- ARINC channels (x4Tx / x4 Rx) for FCC and ACEs interfaces
- Discrete signals mode/status feedback, and potential cockpit interfaces (x5)
- Discrete signal for brake control and brake status. These discretes shall be totally segregated from ECU, either wires, boards, harnesses, etc.
- If neccesary, additional necessary interfaces for control and monitoring of the actuator for example: analog signals, LVDTs... (TBD). These shall be sued for actuator internal purposes.
- Supplied with 270VDC.

The space envelope available for the ECU is 179 mm x 56 mm x 153 mm.

For both types of ECU (spoiler and aileron) a number of units will be needed for rig, qualification, A/C integration and spares, as per table below.

Hardware Deliverables	Rig	Qualification	Total Units
ECU EMA Aileron	2	3	5
ECU EMA Spoiler	4	3	7

Table 10:Nr of units to be delivered

The ECU shall have thermal protections to eliminate the fire risk under abnormal operation.

- <u>Level of integrity</u>

For the HW and SW, DO-254 and DO-178C will be applicable. The design assurance level for the Aileron and Spoiler ECU will be DAL A.

Even though DO-254 and DO-178 certification for aileron and spoiler ECU is out of the scope of this call, the design of the ECUs shall comply with the neccesary requirements to achieve the required assurance level.

- <u>Qualification requirements</u>

The minimum qualification requested will be the necessary to ensure the safety of flight condition and will be agreed with the partner. As a reference, next tables summarises general requirement for the ECU design.

Tasks		
	Test Document Reference	***Category: Equipment in wing/fuselage fairing***
Endurance	(*)	
Fatigue	(*)	
Performances	(*)	
Temperature Altitude	RTCA-DO160 D Section 4	C2
Temperature variation	RTCA-DO160 D Section 5	A
Humidity	RTCA-DO160 D Section 6	C
Operational Shock and Crash Safety	RTCA-DO160 G Section 7	B
Vibration	MIL-STD-810F	(*)
Explosion proofness	RTCA-DO160 D Section 9	Environment II
Waterproofness	RTCA-DO160 D Section 10	R
Fluids Susceptibility	RTCA-DO160 D Section 11	F
Sand & Dust	RTCA-DO160 D Section 12	D
Fungus Resistance	RTCA-DO160 D Section 13	F
Salt spray	RTCA-DO160 D Section 14	S
Icing	RTCA-DO160 D Section 24	B
Magnetic Effect	RTCA-DO160 G Section 15	Z
Voltage Spike	RTCA-DO160 G Section 17	A
Audio frequency conducted susceptibility	RTCA-DO160 G Section 18	R
Induced Signal Susceptibility	RTCA-DO160 G Section 19	ZC
Radio Frequency Susceptibility (radiated and conducted)	RTCA-DO160 G Section 20	YG
Emission of radio frequency energy	RTCA-DO160 G Section 21	H
Lightning Induced Transient Susceptibility	RTCA-DO160 G Section 22	A4G4L4 + Pin Injection WF2 750V/50A

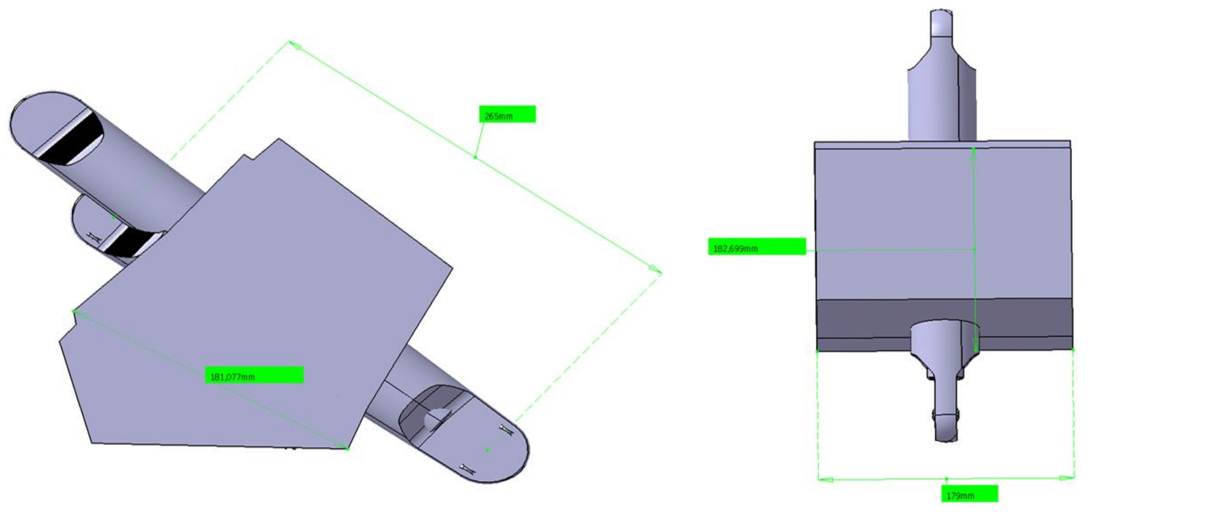
Tasks		
	Test Document Reference	***Category: Equipment in wing/fuselage fairing***
Electrostatic Discharge	RTCA-DO160 G Section 25	A

(*) Customized profiles will be delivered for this purpose

MANUFACTURING OF MECHANICAL PARTS FOR EMA/SHA AILERON AND SPOILER

Both EMAs are electromechanical linear actuator based on BLDC motors supplied with 270VDC.
The Aileron EMA will replace one aileron servo actuator per semi-wing, so same basic design requirements are requested. This actuator shall have an integrated fail safe brake. In order to ensure that in case of failure this actuator is not blocking the total surface movement, the actuator shall make an opposing force when the other actuator is trying to move the surface.
The Spoiler EMA design is composed by two surfaces per semiwing, each one driven by one spoiler actuator. The Spoiler EMA will cover ground spoiler and roll spoiler functions.

The installation space envelope for the aileron and spoiler EMAs included below for reference.



EMA Envelope

The Aileron SHA (Servo-Hydraulic Actuator) will be a back up for the aileron EMA and will include an artificial sensing unit in order to implement the control solution in aircraft.

Hardware Deliverables	Rig	Qualification	Total Units
EMA Aileron	2	3	5
SHA Aileron + artificial sensing	4	1	5
EMA Spoiler	4	3	7

SELECTION AND VALIDATION OF ELECTROMECHANICAL ACTUATORS AND ITS ASSOCIATED CONTROL UNITS FOR BOTH WINGLET AND FLAP TABS.

This call will cover the selection, and validation of electromechanical actuators for both winglet and flap tabs. The main characteristics of both are summarized in the table below.

ELECTROMECHANICAL ACTUATORS PRELIMINARY REQUIREMENTS

- One single EMA shall be valid for both winglet and flap tab and shall comply with the requirements of both applications as described below:

- Performance requirements
  - The EMA shall be sized for the worst case operation: most critical requirement between both appications in terms of velocity and torque shall be taken as requirement for motor sizing.

Winglet EMA

- The following operating points are defined for the EMA Winglet:

Speed (°/s)	**Torque (Nm)**
0	>180 Nm
12°/s	180 Nm
30°/s	No load

- This profile will have an intermittent operation with a continuos offset. This offset corresponds to the hinge moment produced by the external aerodynamic forces that produces deviate the surface from its 0° position. To maintain the 0° position, the EMA is required to act of the surface with a continuos offset estimated next:
  - For 294 kts, the aerodynamic forces produce a hinge moment of 86 Nm.
  - For 244 kts, the aerodynamic forces produce a hinge moment of 63 Nm.
  - For 185 kts, the aerodynamic forces produce a hinge moment of 41 Nm.

Flap Tab EMA

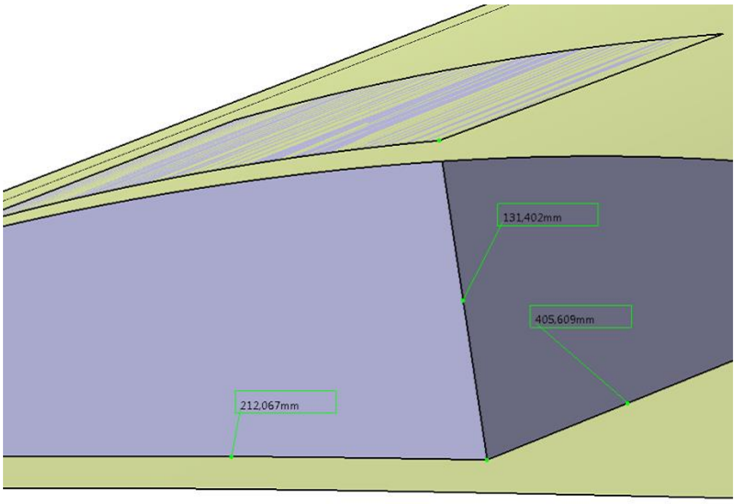
- The following operating points are defined for the Flap Tab EMA:

Speed (°/s)	**Torque (Nm)**
0	>70 Nm
46°/s	70 Nm
120°/s	No load

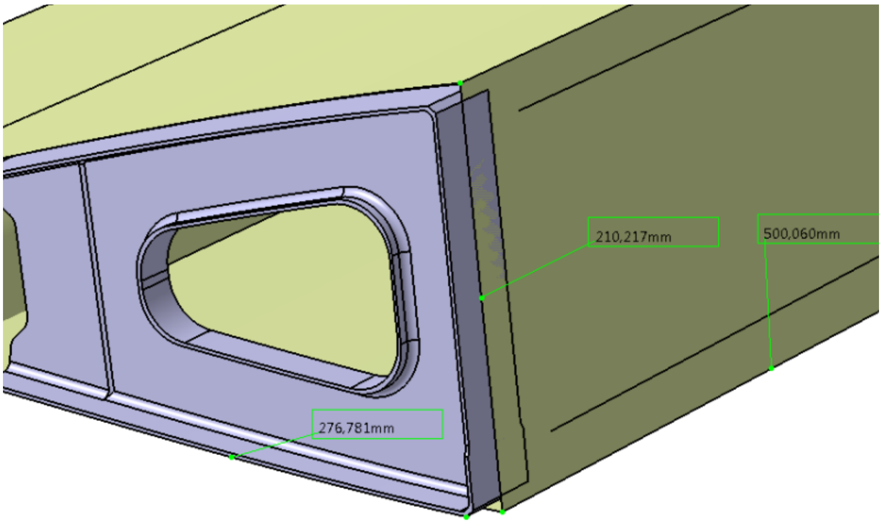
- Architecture and design requirements (flap and winglet)
  - The EMA shall integrate a fail safe brake. It will be used just in case of failure
  - The EMA shall be a rotary actuator, based on BLDC motors and supplied with 28 VDC.
  - The EMA must integrate the necessary sensing means (double RVDT) to perform the control of the actuator. Position control will be performed at higher level by using the embedded RVDT's data.
  - The EMAs for winglet function shall integrate a hinge planetary gear.
  - The control electronics shall be integrated within the envelope of the actuator (see electronics requirements below)

- Space envelope (flap and winglet)
  - The space envelope in which winglet and flap tab actuators will be installed is shown below:

Flap tab:



Winglet tab:



- <u>ELECTRONICS PRELIMINARY REQUIREMENTS</u>

The Electromechanical actuators for winglet and flap tab shall be position controlled. External computer will command speed parameter (actuator extension and retraction rate). The actuator integrated electronics will be responsible of the implementation of the speed command requested externally. It shall determine the torque and power level to ensure the proper speed requested is achieved and provide the necessary feedback to perform external position control loop (RVDTs data).

- <u>Level of integrity</u>

For the HW and SW, DO-254 and DO-178C will be applicable. The design assurance level will be DAL B according to functions criticality.

- <u>Qualification requirements</u>

The minimum qualification requested will be the necessary to ensure the safety of flight condition and will be agreed with the partner. As a reference, next tables summarises general requirement for the EMA design.

For all types of actuator a number of units will be delivered for rig, qualification, A/C integration and spare, as per table below.

Hardware Deliverables	Rig	Qualification	Total Units
EMA Flap tab	4	3	7
EMA Winglet tab	2	3	5

Table 11:Nr of units to be delivered

Tasks		
	Test Document Reference	***Category: Equipment in wing/fuselage fairing***
Endurance	(*)	
Fatigue	(*)	
Performances	(*)	
Temperature Altitude	RTCA-DO160 D Section 4	C2
Temperature variation	RTCA-DO160 D Section 5	A
Humidity	RTCA-DO160 D Section 6	C
Operational Shock and Crash Safety	RTCA-DO160 G Section 7	B
Vibration	MIL-STD-810F	(*)
Explosion proofness	RTCA-DO160 D Section 9	Environment II
Waterproofness	RTCA-DO160 D Section 10	R
Fluids Susceptibility	RTCA-DO160 D Section 11	F
Sand & Dust	RTCA-DO160 D Section 12	D
Fungus Resistance	RTCA-DO160 D Section 13	F
Salt spray	RTCA-DO160 D Section 14	S
Icing	RTCA-DO160 D Section 24	B
Magnetic Effect	RTCA-DO160 G Section 15	Z
Voltage Spike	RTCA-DO160 G Section 17	A
Audio frequency conducted susceptibility	RTCA-DO160 G Section 18	R
Induced Signal Susceptibility	RTCA-DO160 G Section 19	ZC
Radio Frequency Susceptibility (radiated and conducted)	RTCA-DO160 G Section 20	YG
Emission of radio frequency energy	RTCA-DO160 G Section 21	H
Lightning Induced Transient Susceptibility	RTCA-DO160 G Section 22	A4G4L4 + Pin Injection WF2 750V/50A
Electrostatic Discharge	RTCA-DO160 G Section 25	A

2. Scope of work

Ref. No.	*Title - Description*	*Due Date*
1	Requirement Analysis and Preliminary Design (Motors and ballscrews)	M1
2	Requirement Analysis (Winglet and Flap tab EMA's)	M1
3	Requirement Analysis and Preliminary Design (EMA ECU's)	M1
4	Detailed design ballscrew and motors	M3
5	Manufacturing plan and schedule (Aileron EMA, SHA and Spoiler EMA)	M3
6	Overall Risk analysis	M3
7	EMA Selection for Winglet and Flap tabs	M3
8	ECU, motor and ballscrew CDR deliverables	M6
9	Test plan and Procedure	M6
10	Delivery of parts (initial configuration) Aileron EMA, SHA and Spoiler EMA)	M9
11	Manufacturing and Delivery of parts (motors and ballscrews)	M9
12	Delivery of flap tap EMA	M9
13	Delivery of ECU	M12
14	Delivery of Winglet EMA	M12
15	Delivery of parts (final configuration) Aileron EMA, SHA and Spoiler EMA)	M12
16	Test reports and DDP	M18
17	Suppot to ground test rig integration	M24

The project will begin with the analysis requirements regarding manufacturing of FCS parts. The project will define the optimum manuacturing routes . Alternative materials and proceses will be analysed an discussed with the Topic manager being the final objective the optimization of manufacturing costs, raw materials and environmental protection. With this purpose different aproaches will be considered including novel manufacturing processes as additive manufacturing. The partner will also propose and collaborates in alternatives redesign activities ir order to reach the expected goals.

Once the manufacturing processes and routes have been completely defined and approved by the topic manager , the selected partner will be responsible of the manufacturing of the different mechanical parts . Please be aware that neither the electrical motors nor the screws will be included among the parts to be manufactured. The project will support the Topic manager during the final assembly and tests.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
1	Requirement Analysis and Preliminary Design (Motors and ballscrews)	Doc	M1
2	Requirement Analysis (Winglet and Flap tab EMA's)	Doc	M1
3	Requirement Analysis and Preliminary Design (EMA ECU's)	Doc	M1
4	Detailed design ballscrew and motors	Doc	M3
5	Manufacturing plan and schedule (Aileron EMA, SHA and Spoiler EMA)	Doc	M3
6	Overall Risk analysis	Doc	M3
7	EMA Selection for Winglet and Flap tabs	Doc	M3
8	ECU, motor and ballscrew CDR deliverables	Doc	M6
9	Test plan and Procedure	Doc	M6
10	Delivery of parts (initial configuration) Aileron EMA, SHA and Spoiler EMA)	HW	M9
11	Manufacturing and Delivery of parts (motors and ballscrews)	HW	M9
12	Delivery of flap tap EMA	HW	M9
13	Delivery of ECU	HW	M12
14	Delivery of Winglet EMA	HW	M12
15	Delivery of parts (final configuration) Aileron EMA, SHA and Spoiler EMA)	HW	M12
16	Test reports and DDP	Doc	M18
17	Suppot to ground test rig integration	Doc	M24

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
1	Overall Projectschedule		M1
2	Risk analysis		M3
3	Critical Design Review		M6
4	Delivery of parts		M9
5	Delivery of parts (ECU and Winglet tap EMA)		M12
6	Test reports and DDP		M18

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

- ✓ Demonstrated experience (based on history) in design and manufacturing of airborne equipment qualified under RTCA-DO-160, RTCA-DO-178, and RTCA-DO-254 for critical equipment or other civil or military equivalent standards.• Capacity to assembly and testing complex aeronautical equipment.
- ✓ Experience in equipment showing compliance with Electrical Power Normative MIL-STD-704F power quality.
- ✓ Design and analysis tools of the aeronautical industry.
- ✓ Competence in management of complex projects of research and manufacturing technologies.
- ✓ Experience in integration multidisciplinary teams in concurring engineering within reference aeronautical companies.
- ✓ Proven experience in collaborating with reference aeronautical companies, industrial partners, technology centers within last decades in: Research and Technology programs (TRL Reviews)
- ✓ Industrial air vehicle with "in – flight" components experience.
- ✓ Capacity to support documentation and means of compliance to achieve prototype "Permit to Fly" with Airworthiness Authorities (FAA, EASA…).
- ✓ Capacity to specify components and systems tests along the design and manufacturing phases of aeronautical equipment's, including: Characterization of innovative materials, Equipment type tests (vibration, temperature humidity, etc.),Advanced instrumentation systems, Impact tests (i.e. low energy tests)
- ✓ Capacity to repair "in-shop" equipment due to manufacturing deviations.
- ✓ Capacity to support to Air vehicle Configuration Control
- ✓ Quality System international standards
- ✓ Capacity of performing Life Cycle Analysis (LCA) and Life Cycle Cost Analysis (LCCA) of materials and structures, and systems.
- ✓ Capacity of evaluating results in accordance to Horizon 2020 environmental and productivity goals following Clean Sky 2 Technology Evaluator rules and procedures
- ✓ Experience with mechanical, electrical, and thermodynamic (modeling and simulation tools

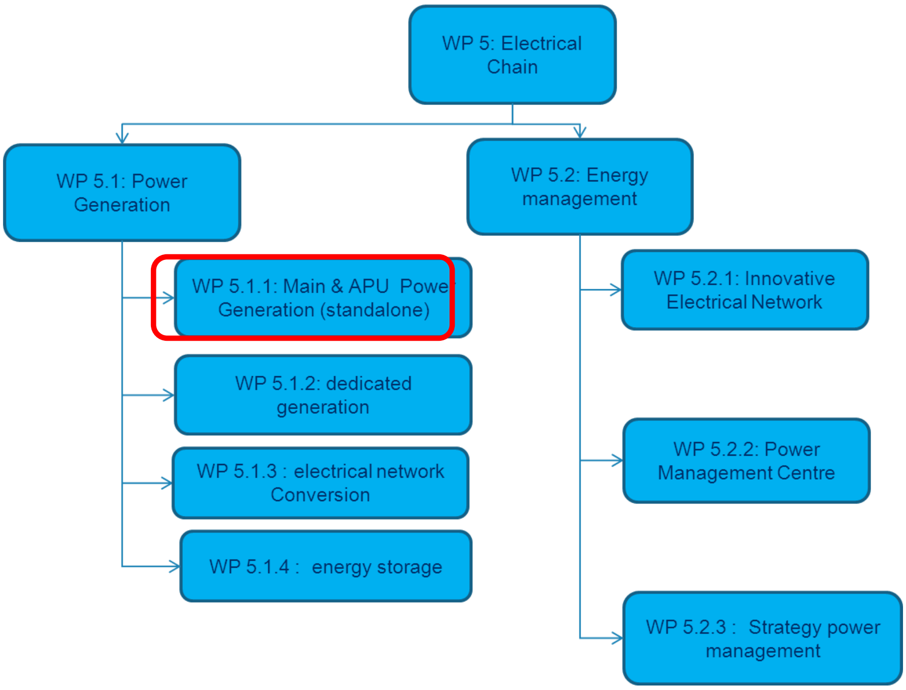
III. Smart Oil pressure sensors for oil cooled starter/generator

Type of action (RIA or IA)	IA		
Programme Area	SAT		
Joint Technical Programme (JTP) Ref.	WP 5.1.1		
Indicative Funding Topic Value (in k€)	600 k€		
Duration of the action (in Months)	18 months	**Indicative Start Date**[55]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-SYS-02-15	**Smart Oil pressure sensors for oil cooled starter/generator**
Short description (3 lines)	
Development and test of a smart oil pressure sensor technology that will have to operate in harsh environment (temperature, pressure, vibration …). This sensor will have to integrate" Health Monitoring" capability in order to allow failures detection and prediction.	

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

1. Background



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

As starting point, future Aircraft will need more electrical power on board. Consequently, the associated electrical rotating machine power will increase. Oil cooling machines seems the solution as it enables more compact machines, along with long bearing life and higher rotation speeds. Today the rotating electrical machine manufacturers have implemented oil cooling system comprising hydraulic pump, regulator valve, and filters. In order to monitor the proper running of the cooling system oil pressure indicators can be implemented into the machine.
Standard technology is limited for aircraft applications because of different reasons as industrial environment (limited operating temperature) and electrical interface by using electronic treatment inside the sensor. Current technology is also based on on/off switch working at a set pressure and does not allow to anticipate any failure. The actuation thresholds are fixed and cannot be set up according to the real conditions of the

machine (variation of temperature, speed…).

In this aim, a smart oil pressure sensor technology must be developed able to make Health Monitoring of the cooling system. Functional requirements are the followings:

Smart pressure sensor application: 0,5 to 8 bar

Smart differential sensor application: 0,5 to 5 bar

In both applications the accuracy pressure output (current or voltage, values defined later) must be better than 5% on the whole operating temperature range.

This smart sensor technology must be compliant with very severe environmental constrain:

Sensor operating temperature: -40°C to +180°C

Electronic data processor operating temperature:

Full integrated option (preferred): -40°C to +180°C

Separated box option: -55°C to +125°CVibration level: DO160 category U&W with amplification factor of 500% from 150 to 300Hz.

EMC : compliant with D0160 standard

Hydraulic fluid to be monitored: turbine oil MIL-PRF-7808 and MIL-PRF-23699

The sensor is placed in an oil mist environment (oil mist of turbine oil MIL-PRF-7808 and MIL-PRF-23699)

The goal of this topic is to find partner(s) able to develop the technology and demonstrate a high level of maturity on two demonstrators: one oil pressure sensor and one differential pressure sensor and their data processor (Integrated solution preferred)

TRL5 is expected at the end of the project.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 1	**Specification freeze** the topic manager and the partner(s) shall contribute to freeze the specification	T0 + 1 Month
Task 2	**State of the art** Applicant is requested to investigate general state of the art of sensors and data processing for oil pressure application. At the end of this phase, the partners shall provide a choice matrix justifying the technology choice according to the specification criteria provided in task 1.	T0 + 2 Months

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 3	**Preliminary design** Applicant is requested to develop a mock-up able to demonstrate the accuracy of the technology selected. Applicant shall provide a preliminary design analysis including functional justification, mechanical calculation, drawings and electronic schematics. All the justification shall be based on a DFMEA.	T0 +6 Months
Task 4	**Design** Applicant is requested adapt the selected technology for the two applications identified according to the specification. Applicant shall provide updated design justifications and applied on whole sensor perimeter.	T0 + 9 Months
Task 5	**Demonstrator manufacturing** Applicant is requested to manufacture at least 5 demonstrators of each application. Two of each will be transmitted to Topic Manager for integration tests. The remaining parts will be dedicated to the partner(s) for qualification tests.	*T0 +15 Months*
Task 6	**Qualification tests** Applicant is requested to carry-out qualification tests on the two part numbers including: - Performance at low and high temperature - Vibration - EMC susceptibility - Endurance (vibration, pressure cycling, pollution, temperature cycling, altitude….) - Robustness (Vibration and temperature) Applicant shall provide test reports and examination reports.	*T0 +18 Months*

3. Major deliverables and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	State of the Art	document	T0 + 2 Month
D2	Technology choice matrix	component	T0 + 4 Months
D3	Preliminary technology design justification	document	T0 + 6 Months
D4	Sensors design justification	document	T0 + 10 Months
D5	2 Demonstrators of each sensor delivery	hardware	T0 + 15 Months
D6	Tests and examination reports	document	T0 + 18 Months

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
KOM	Kick Off meeting		T0
PDR	Predesign review : sensor architecture and technology selection		T0+6 months
CDR	Design review : sensor definition and Test bench design freeze reproducing environmental conditions (mechanical constraints and temperature variation, dedicated or combined conditions)		T0+10 months
TRR	Test readiness review : test specification freeze.		T0+15 months
QR	Qualification review : Tests results and reports		T0+18 months

4. <u>Special skills, Capabilities, Certification expected from the Applicant</u>

The applicant should have the following knowledge & equipment:

- Strong knowledge of sensors technology and data processing
- Strong knowledge and extensive experience on mechanical calculation and EMC electronic design
- Strong knowledge in product development and design tools (Development plan, Product and process FMEA)
- Facilities to conduct fatigue and combined robustness tests

The applicant should have the following experience in management project:
The activity will be managed with a Phase & Gate approach and management plan has to be provided. The Topic Manager will approve gates and authorise progress to subsequent phases.
Technical and programme documentations, including planning, drawings, FMEAs, manufacturing and inspection reports, must be made available to the Topic Manager.
Experiences in R&T and R&D programs. Experience of aerospace related research programs would be an advantage. In-house testing capability will have to be emphasized in order to propose an integrated design, manufacturing and testing approach.
Availability of test benches to support test campaigns is mandatory.
English language is mandatory.
Activities shall be conducted using ISO standards.

IV. Optimization two phases cooling solution using micro pump brick

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP 5.1.1		
Indicative Funding Topic Value (in k€)	800 k€		
Duration of the action (in Months)	18 months	**Indicative Start Date**[56]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-SYS-02-16	**Optimization two phases cooling solution using micro pump brick**
Short description (3 lines)	
The subject of this CfP deals with on the miniaturization of a diphasic loop with the aim to transfer and dissipate the calories of a power converter. This micro diphasic loop will be plugged with our power converter in a minimized volume. The micro diphasic loop weight target is 2.5 kg, it will integrate a micro pump, expansion tank, condenser, evaporator, piping and mechanical structure. This micro diphasic loop will also have to take into account our aeronautical constraints such as the altitude, ambient temperature and vibrations among others.	

1. Background

Traditionally, aeronautical power electronics use liquid and/or air forced cooling systems. These techniques are proven, reliable and robust technology but drawbacks are overweight and limited efficiency to extract heat flow generated in high power and dense converters.
This call for proposal consists on studying and developing demonstrators of cooling system based on biphasic techniques in order to reduce drastically thermal constrains, weight and dimensions of high dense power electronics modules.

This cooling technique, initially developed for space application, becomes promising solution for MEA concept that allow densification and growth of onboard power without overweight for thermal issue.
The gain of mass, in aeronautical domain, is an important stake, that's why we wish with this new CfP to reduce the mass of a factor 3 and to extract much more calories.

This CfP is a scientific and industrial challenge, which provides opportunity of competitiveness on this important improvement part of power electronics dedicated for more electrical aircraft for European partners of Clean Sky.

2. Scope of work

Aeronautical constraints are diverse and the diphasic loop will have to consider them for that design.
The diphasic loop will have to come integrated into a set of dimension L x l x H = 297 x 210 x 210 mm and to have no mass exceeding 2.5kg.
The miniaturized evaporator will have to extract a power density of 85 W/cm² in surface of silicon chip and the fan will not owe generated more of 20g/s.
The performance of the diphasic loop will have to be valid on a range of ambient temperature going of -55°C in +70°C.
The difference of the temperature along the electrical component surfaces should not exceed 2°C to 3°C to avoid any heterogeneity in the treatment of the electrical flow and also to avoid any internal thermal expansion.
As all these equipments are mounted in a plane, they should not be sensitive to the gravity and acceleration and also direction of the plane which can be in any position between -30° to +30° in relation to the horizon.
The diphasic loop will be also submitted to various type of mechanical load such as the random vibrations, it being defined in the standard DO160.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 1	**Specification and objective** Validation of the specification and the objectives: Constraints of mass, size enclosure, interface, electrical, thermal, mechanical and environmental.	T0 + 1 Month
Task 2	**Strategy of miniaturization** The partner will present his strategy on the miniaturization of every component of the diphasic loop: the pump, the expansion tank, the evaporator and the condenser. He will present the technical and technological levers of optimization chosen as well as his selected suppliers.	T0 + 2 Months
Task 3	**Preliminary design** The partner will present of the miniaturized components integrated following the specified constraints.	T0 +5 Months
Task 4	**Critical design** The partner will present the diphasic loop in his set (mechanical frame and cover) following the specified constraints.	T0 + 8 Months
Task 5	**Demonstrator** 3 demonstrators will be requested: 2 demonstrators will be used by Thales for electrical test. 1 other will be used by the partner to carry out the qualification of the diphasic loop.	*T0 +14 Months*
Task 6	**Qualification test** Mechanical tests : - Vibrations - Static acceleration - Reliability - Environmental (Corrosion, flammability, etc.) - Robustess Thermal tests : - Performance in low temperature - Performance in high temperature - Robustess Electromagnetic tests	*T0 +18 Months*

3. Major deliverables / Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	**Justification report of the preliminary design** This document of justification will integrate, the context, the presentation of the components of the diphasic loop miniaturized, the technical justification of the design miniaturized, the ways of optimization to go towards the final design as well as an estimate of the possible gain for the final design.	Document	T0 + 6 Month
D2	**Justification report of the final design** This document of justification will integrate, the synthesis of the preliminary justification, the presentation of the components of the diphasic loop miniaturized, the technical justification of the design miniaturized, the comparison between the preliminary and final design, the performance reached on characteristic loading cases.	Document	T0 + 10 Month
D3	**Supply of the components of the diphasic loop** Supply the evaportor, the pump, the condenser and the expansion tank miniaturized.	Hardware	T0 + 14 Month
D4	**Justification report of manufacturing** This document will present the process of manufacturing of every component, the assembly of the diphasic loop, the procedure of filling of the loop, the cost of the various posts of manufacturing and assembly, the cost of the end product for a definite quantity.	Document	T0 + 15 Months
D5	**Supply of 2 demonstrators** Supply 2 diphasic loop integrated in his framing.	Hardware	T0 + 15 Months
D6	**Test report of qualification** This document will present the used test benches, the instrumentation realized for every test and the obtained results.	Document	T0 + 18 Months

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
KOM	**Kick Off meeting** Presentation of the purpose, compliance matrix and the schedule over 18 months.	Meeting	T0
PDR	**Preliminary Design Review** Presentation of the preliminary design: design, studies, tests, performances of the diphasic loop in his framing. Presentation of the ways of improvement.	Meeting	T0+5 months
CDR	**Critical Design Review** Presentation of the final design: design, studies, tests, performances, of the diphasic loop in his framing.	Meeting	T0+8 months
TRR	**Test Readiness Review** Presentation and review of the test plan. Presentation of the test benches, the instrumentation and the standards to be used.	Meeting	T0+10 months
QR	**Qualification review** Presentation of the results of qualification test.	Meeting	T0+18 months

4. Special skills, Capabilities, Certification expected from the Applicant

For this study, the applicant shall satisfy following minimum criteria:

- ✓ Good background and experience in miniaturized mechanically pumped diphasic cooling system,
- ✓ Technological Readiness Level of mechanically pumped diphasic cooling system (components and system) should be high enough, minimum 4, expected 5.
- ✓ Insurance shall be provided to manage this work in time without delay for the development phases
- ✓ Adequate equipment and tools for thermal, electrical and mechanical simulations for the equipment and the global system behaviour,
- ✓ Adequate equipment for the manufacture and test of the equipments under quality control.
- ✓ Adequate test benches to develop and test requested demonstrators in respect with milestone of delivery,
- ✓ Available resources to execute the respective tasks should be stated in the proposal.

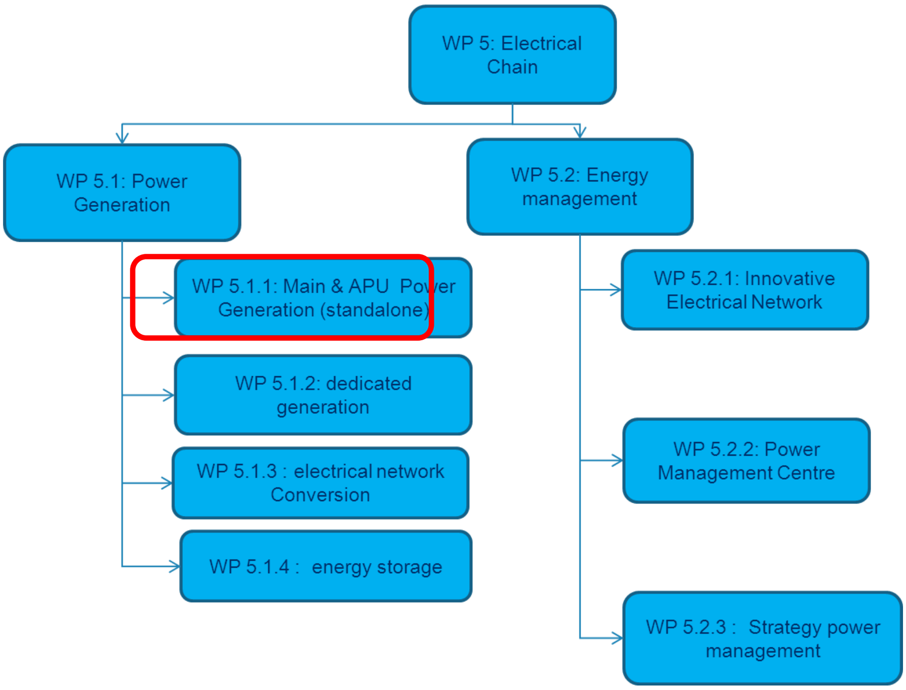
V. Innovative pump architecture for cooling electrical machine

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP 5.1.1		
Indicative Funding Topic Value (in k€)	800 k€		
Duration of the action (in Months)	30	**Indicative Start Date**[57]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-SYS-02-17	**Innovative pump architecture for cooling electrical machine**
Short description (3 lines)	
Due to continuous electric power need growth aboard aircrafts, industrials are looking for renewed pump design fitting to high power machines oil cooling systems and allowing to optimize mass, durability, and availability as required by aircraft manufacturers.	

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

1. Background



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

These days due to continuous electric power need growth aboard aircrafts, generation system and more specifically VFSG (variable frequency starter generator) are asked to deliver more and more power. Consequently these machines power loss through diverse heating phenomena (copper losses, Eddy current losses, mechanical frictions…) grows as well. For these reasons aircraft power generation industrials are looking for renewed oil cooling systems fitting to these high power machines and allowing to optimize mass, durability, and availability as required by aircraft manufacturers.

Thus in regards to new high power VFSG developments industrials need to be provided with innovative pump design allowing:
- pump integration scale reduction for easier installation inside machine and lower impact on overall machine envelope and design complexity
- pump maximum moving parts number reduction for higher durability and availability
- pump efficiency optimization

For instance these goals may be reached by using pump without body directly installed inside oil tank, and pump rotating at higher speed avoiding the use of reduction to adapt to the machine speed, but possible design are numerous and Topic Manager will expect the most exhaustive study as possible going through:
- state of the art analysis
- pump innovative design architectures score card
- preferred design (possibly two TBC) selection, specification and definition
- prototype manufacturing and testing

Required performances
- 23l/min minimum flow
- above 10 bars output pressure
- operational speed range x2,1

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** the topic manager and the partner(s) shall contribute to freeze the specification	T0 + 1 Month
Task 2	**State of the art** Applicant is requested to investigate general state of the art of oil pump. At the end of this phase, the partners shall provide a choice matrix justifying the technology choice according to the specification criteria provided in task 1.	T0 + 4 Months
Task 3	**Preliminary design** 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 a mock-up able to demonstrate the compliance of the technology selected.	T0 + 8 Months
Task 4	**Design** Applicant shall provide finalized design data justifications (and DFMEA) in order to manufacture a fully compliant prototype	T0 + 20 Months
Task 5	**Prototypes manufacturing** Applicant is requested to manufacture at least 3 prototypes (1 to be given to topic manager for internal test)	T0 +24 Months
Task 6	**Qualification tests** 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) Applicant shall provide test reports and examination reports.	T0 +30 Months

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	State of the Art	document	T0 + 3 Month
D2	Technology choice matrix	component	T0 + 4 Months
D3	Preliminary design and justification dossier	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 and justification Dossier	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, Capabilities, Certification expected from the Applicant

The applicant should have the following knowledge & equipment:
- 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,

The applicant should have the following experience in management project:
The activity will be managed with a Phase & Gate approach and management plan has to be provided. The Topic Manager will approve gates and authorise progress to subsequent phases.
Technical and programme documentations, including planning, drawings, FMEAs, manufacturing and inspection reports, must be made available to the Topic Manager.
Experiences in R&T and R&D programs. Experience of aerospace related research programs would be an advantage. In-house testing capability will have to be emphasized in order to propose an integrated design, manufacturing and testing approach.
Availability or design and manufacturing of test benches to support test campaigns is mandatory.
English language is mandatory.
Activities shall be conducted using ISO standards.

VI. Eco Design: Injection of thermoplastic reinforced with long fibers (carbon, glass, Kevlar…) for scroll reinforcement

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 k€		
Duration of the action (in Months)	36 months	**Indicative Start Date**[58]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-SYS-02-18	**Eco Design: Injection of thermoplastic reinforced with long fibers (carbon, glass, Kevlar…) for scroll reinforcement**
Short description (3 lines)	
The aim of this topic is to integrate long fibers in parts manufactured in thermoplastic (e.g. PEEK) by injection process. The objective is to manufacture a thermoplastic scroll and locally reinforce it with long fibers (carbon, glass, kevlar…). This will allow replacing current metallic parts by thermoplastic to reduce the part weight, cost and avoid surface treatment.	

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

1. **Background**

Air cycle machines (ACM) used in air cooling systems integrates usually one of several thermodynamic stages (turbine or compressor) composed of a wheel (rotating part), a potential stator stage (injector or diffuser) and a scroll (See Fig. 1).

The scroll is a circumferential static part surrounding the wheel and the stator stage and supplying air to (turbine) or collecting air from the stage.

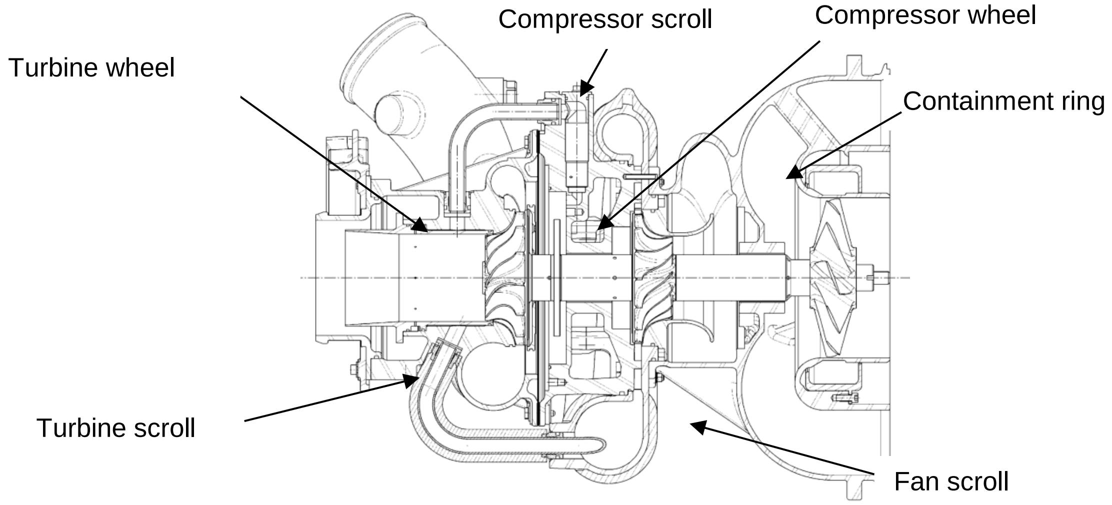


Fig. 1: Cross section of an Air Cycle Machine (ACM).

Scrolls are generally manufactured in aluminium casting which requires surface treatments using and containing the CMR compounds Cr6+(CAA, Alodine). In order to reduce weight and cost of the parts but also to prevent the need of hazardous surface treatments, the Topic manager has manufactured in the frame of Clean Sky 1 a turbine scroll by injection moulding with PEEK reinforced with short carbon fibres. This part is able to sustain pressure up to 5 bars. However, new Air Cycle Machines genreration requires to resist at higher pressure level (up to 10 bars) and higher temperature (up to 200°C). Also, the fan scroll integrates containment ring in stainless steel (fig.1). In order to reduce weight of the ACM, it would be interesting to replace all metallic scrolls by thermoplastic scrolls. But this requires to reinforce locally the turbine and compressor scroll for pressure and temperature resistance and fan scroll for containment.

This could be done by integrating long fibers in parts manufactured in thermoplastic (e.g. PEEK) by injection process.

The aim of this CfP is to find partner(s) that will propose a 3 years research program for developing this solution.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 1	Definition of the requirement	M2
Task 2	Choice of the scroll	M6
Task 3	Definition, conception and manufacturing of a model part	M12
Task 4	Characterization and testing of the model part	M18
Task 5	Definition, conception and manufacturing of a scroll	M36
Task 6	Characterization and testing of the final demonstrator	M36

Task 1: Definition of the requirements

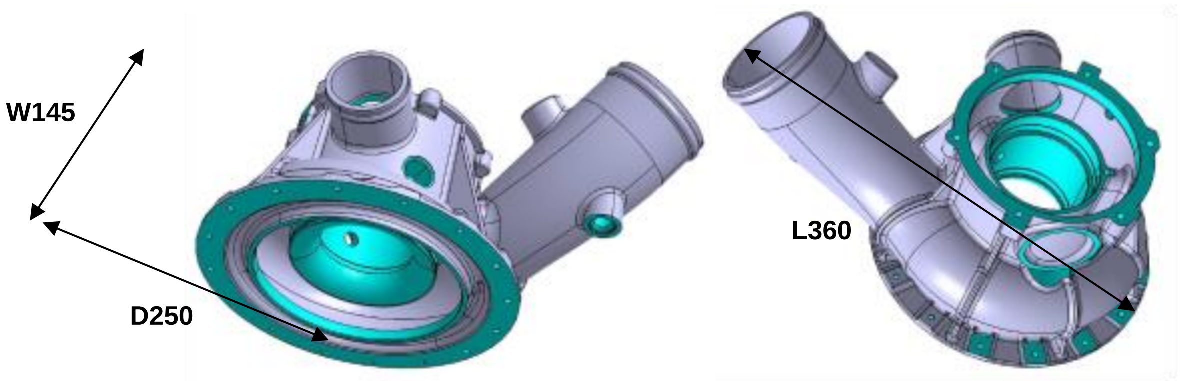
At the beginning of the project, the Topic manager will define the following requirements:

- Nature of the material with PEEK family
- Conditions during service : pressure, temperature, atmosphere, containment resistance…

Task 2: Choice of the scroll

The choice of the scroll that will be manufactured will be done in collaboration with the Topic manager and according to the feasibility of the part with respect to the technology. The technical requirements and current drawing related to the selected part will be provided by the Topic manager to the applicant. Potential dimensions of the scroll are D250*L360*W145.

Only one scroll will be chosen among turbine, compressor and fan scroll. It will be able to demonstrate it compliancy with requirements defined in task 1.



Task 3: Definition, conception and manufacturing of a model part

A simplified model part integrating long fibers placement will be defined. This model part will be able to resist at the 3 main sollicitations (pressure 10bars, pressure 10bars+temperature 200°C and containment). Different natures of fibers will be selected according to the sollicitation investigated. This work will be done in collaboration with the Topic manager.

A mold will be designed and manufactured according to the defined model part. The design of the mould will take into account the integration of the reinforcement part.

The long fibers reinforcement will probably require a specific design and manufacturing (e.g. complex preform).

Task 4: Characterization and testing of the model part

In order to test the model part, it will be mandatory to define with the Topic manager and according to requirements defined in task 1, the testing protocol. These tests will include pressure (for turbine scroll), pressure + temperature (for compressor scroll) and containment (for fan scroll) resistance.

Testing will allow to demonstrate that the model part complies with the requirements defined in Task 1.

Task 5: Definition, conception and manufacturing of a scroll

According to the knowledge of the applicant on the constraints related to the process and to the results of task 4, modification of the current scroll design and its reinforment could be proposed by the applicant with the collaboration of the Topic manager. Final design will be validated by the Topic manager according to stress calculations.

Then the applicant will design an injection mould able to integrate long fibers reinforcement according to the final design of the part and outputs of task 3. This step shall include rheological simulations. The applicant will manufacture the mould accordingly.

First scroll prototypes will be manufactured and characterized with destructive and non-destructive technologies (e.g. tomography). The number of first scrolls will be defined by the applicant but it should be sufficient:

- To check the thickness homogeneity (especially thickness of the scroll walls),
- To check the position of the reinforcement,
- To control geometry and its compliancy with the defined design,
- To identify potential defects (porosity, fibres repartition, quality of the interface reinforcement/injected material...). A specific protocol could be proposed to control the position of the reinforcement.

The design of the mould and of the reinforcement, as well as process parameters will be modified and optimized according to the previous step.

This steps will be repeated as much as necessary to obtain a part compliant with the requirements (thickness homogeneity, geometry & no defect…). This iterative process will be ended with the final definitions of the mould, design of the part and its reinforcement.

When the process will be secured and optimized, the applicant will manufacture 20 scroll demonstrators.

The applicant will demonstrate its capacity to transfer the process to an industrial scale and to ensure aeronautical production rates. An economic analysis will be done by the applicant.

Task 6: Characterization and testing of the final part

The geometry of the 20 demonstrators will be checked by the applicant with non-destructive technologies.

A final demonstrator could be tested by the applicant in specific test benches (pressure, pressure + temperature, containement).

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D0.1	Minutes of KOM	R	M0
D1	Definition of requirement	R	M2
D2	Choice of the scroll	R	M6
D3.1	Design of the Model part	R	M8
D3.2	Model Part	D	M12
D3.3	Intermediate Report	R	M12
D4	Intermediate Report +Test results on model part	R	M18
D5.1	Design of the scroll	R	M20
D5.2	First scroll prototypes and quality control	D + R	M30
D5.3	Final demonstrators and dimensional control	D + R	M36

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Model part tested	Milestone	M12
M2	First scroll prototype available	Milestone	M30

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 thermoplastic injection moulding (injection process, design and manufacturing of the moulds, calculation, rheological simulation)
- ✓ Knowledge on long fibers placement for reinforcement with injection thermoplastic process.
- ✓ Strong knowledge on PEEK reinforced with short fibers and its manufacturing by injection moulding.
- ✓ Capabilities for injection moulding, mould design and manufacturing of mould.
- ✓ Extensive experience on and capabilities for characterisations (thickness homogeneity, geometry, identification of potential defects) by destructive and non-destructive technologies of reinforced thermoplastics
- ✓ Facilities for implementing the processes in an industrial scale and ensuring aeronautical production rates.

VII. Eco Design: Composite functionalization: thermal and electrical conductivity

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 k€		
Duration of the action (in Months)	36 months	**Indicative Start Date**[59]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-SYS-02-19	**Eco Design: Composite functionalization: thermal and electrical conductivity**
Short description (3 lines)	
The main objective of this topic is to functionalize composites (thermoplastics and/or thermosets) introducing conductive particles in the matrix or through special treatment on fibers. In a second step, specific bonding could be investigated when higher conductivity levels are required. The aim is to reduce weight of metallic parts but keeping conductivity properties. Potential application is a valve actuator body for which EMI protection and bonding is required.	

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

1. Background

Environmental control system (ECS) uses many electrical actuators to ensure the control and the tuning of the system performance. The most complex of these actuators are especially composed of (see also figure 1):

- An electrical motor
- A gear box
- A power electronic
- A control electronic
- A housing (or body)

Actuator bodies are currently manufactured with aluminium alloys (see figure 2) which requires surface treatments using and containing the CMR compounds Cr6+ (CAA, Alodine). In order to reduce weight and cost of the parts but also to prevent the need of hazardous surface treatments, the Topic Manager would like to manufacture this part with thermoplastic or thermoset reinforced with short or long fibres. But this composite parts need to be conductive in order to meet EMI protection and bonding requirements.

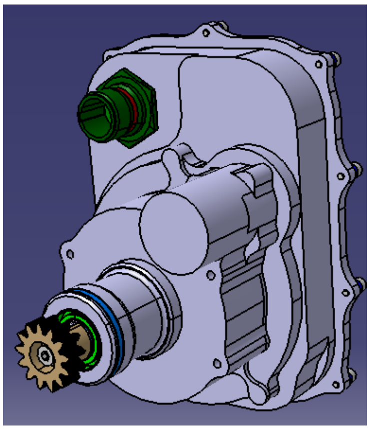


Figure 1: Typical actuator, including one stepper motor and his electronics.

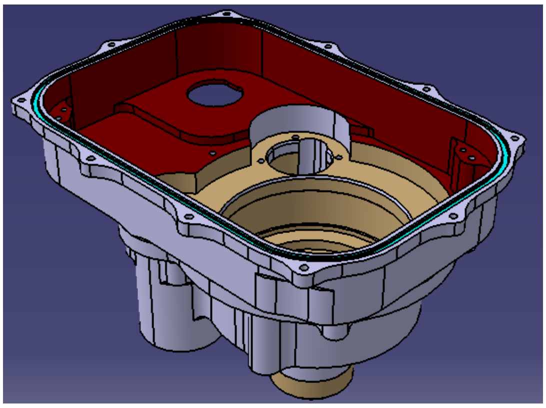


Figure 2: Actuator body in aluminium. Outline volume dimensions : 162x160x100mm

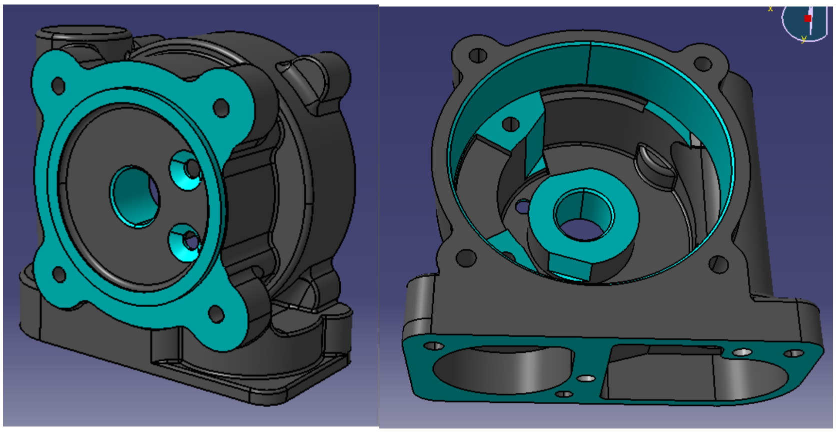


Figure 3 : Typical Peek housing (non compliant with EMI and bonding requirements)

The main objective of this topic is then to functionalize composites (thermoplastics and/or thermosets) introducing conductive particles in the matrix or through special treatment on fibers. In a second step, specific surface bonding could be investigated when higher conductivity levels are required. But the work should be focused on the first way.

The aim of this CfP is to find partner(s) that will propose a 3 years research program for developing this solution.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 1	Definition of the requirement	M2
Task 2	Trade-off: materials (thermoplastics or thermosets), funtionnalization processes (conductive particles, fibers treatment, additional surface bonding…), and manufacturing processes (injection, thermoforming, autoclave / prepreg, RTM…)	M12
Task 3	Manufacturing and characterization of specimens	M18
Task 4	Definition, conception and manufacturing of the actuator	M36
Task 5	Characterization and testing of final demonstrators	M36

Task 1: Definition of the requirements

At the beginning of the project, the Topic manager will define the following requirements:

- EMI protection and bonding requirements.
- Conditions during service : mechanical sollicitations, temperature, atmosphere

- Material resistance according to RTCA/DO-160…

Task 2: Trade-off

This trade off should be made on :

- **Materials :** thermoplastics or thermosets (nature of the matrix and fibers) compliant with the requirements defined in task 1,
- **Funtionalization processes :** several processes should be studied according to the materials choice and the requirements defined in task 1. Among this processes: conductive particles, fibers treatment, additional surface bonding…,
- **Manufacturing processes.** According to the material choice and the Topic manager part design different manufacturing processes could be proposed : injection molding, thermoforming, autoclave/prepreg, RTM…

At the end of this trade-off, materials, functionnalisation and manufacturing processes that will be used during the project will be chosen with the Topic manager. Several materials, functionnalisation and manufacturing processes should be investigated. Criteria that will be used for the choise will be : compliancy with requirements defined in task 1, cost and process maturity.

Task 3: Manufacturing and characterization of specimens

The specimens design will be defined with the Topic manager and will be manufactured according to the choices done in task 2. Several solutions will be investigated.

Characterizations will be proposed to check that the manufactured specimens are compliant with the requirements defined in task 1.

According to the results, 2 or 3 solutions will be selected for task 4.

Task 4: Definition, conception and manufacturing of the actuator

According to the knowledge of the applicant on the constraints related to the process and to the results of task 3, modification of the current actuator design should be proposed by the applicant with the collaboration of the Topic manager. Final design will be validated by the Topic manager according to stress calculations, EMI protection and bonding requirements.

Then the applicant will manufacture and control the actuators bodies with the materials and processes selected in task 3.

These steps will be repeated as much as necessary to obtain a part compliant with the requirements defined in task1.

When the process will be secured and optimized, the applicant will manufacture 10 actuator bodies per selected solutions.

The applicant will demonstrate its capacity to transfer the process to an industrial scale and to ensure aeronautical production rates. An economic analysis will be done by the applicant.

Task 5: Characterization and testing of the model part

The geometry and materials quality of the final parts will be checked by the applicant with non-destructive technologies.

Final parts will be also tested by the applicant in specific test benches.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D0.1	Minutes of KOM	R	M0
D1	Definition of requirements	R	M2
D2	Trade-off	R	M12
D3	Design, manufacturing and characterization of specimens	R + S	M18
D4	Design and manufacturing of actuator bodies	R + D	M36
D5	Characterization of actuator bodies	R	M36

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Trade-off	Milestone	M12

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 thermoplastic and thermosets composites and associated manufacturing processes
- ✓ Extensive experience and strong knowledge on composites functionalization.
- ✓ Capabilities for composite manufacturing processes.
- ✓ Extensive experience and capabilities for characterisations of composites by destructive and non-destructive technologies

Facilities for implementing the processes in an industrial scale and ensuring aeronautical production rates.

VIII. Eco Design: Screening and development of optimized materials (wires, resins and varnishes) for high temperature coils

Type of action (RIA or IA)	RIA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP6 /WP100.2		
Indicative Funding Topic Value (in k€)	500 k€		
Duration of the action (in Months)	36 months	**Indicative Start Date**[60]	Q1 2017

Identification	Title
JTI-CS2-2016-CFP03-SYS-02-20	**Eco Design: Screening and development of optimized materials (wires, resins and varnishes) for high temperature coils**
Short description (3 lines)	
The main objective of this topic is to have a complete solution to have a high temperature coil including a specific wires, impregnating varnishes and potting ingredients (resins). The solution shall be performed for aeronautical constraints (electrical, vibration, lifetime, manufacturing process …) with a temperature of 300°C.	

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

1. Background

Environmental control system (ECS) use many little electromechanical actuators (low power) to assure the control and the tuning. They include also generally motorized turbomachine with power electrical motors.
In the both cases, the temperature class of coils integrated in motors or electromechanical actuators must be increased to optimize the integration and the 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 an exemple of applications :

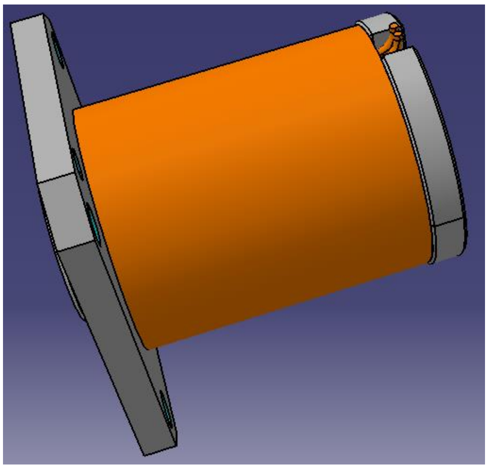


Figure 1: Coil of electromagnet.

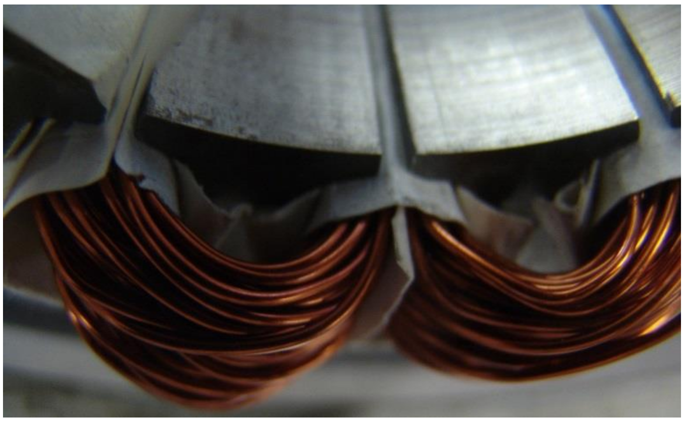


Figure 2 : Motor winding

These products use currently a polymer (polyamide-imide, polyimide) for the magnet wire and the impregnating varnish.

The currently used potting ingredients is an epoxy resin. All the electromechnical actuators do not include a potting product. The potting have 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 with a good insulation to avoid electrical arcing or current leakage.

The objective of this topic is to do a specific varnish for the magnet wire and the impregnating varnish, and a specific potting ingredients for a high temperature (300°C).

These specific varnish and ingredient shall be applied on magnet wires and coils.

These new ingredient shall be complient with "REACH" standards.

First of all, the separate ingredients (magnet wire, impregnating varnishes, potting ingredients) shall be tested with the appropriate standard and method to validate the temperature class and the function.

After, a sample parts of coils (magnet wire+varnish, magnet wire + varnish + potting ingredient) shall be manufactured to validate the temperature class and the function.

Finally, a complete demonstartor shall be manufacted and tested with the new materials.

The aim of this CfP is to find partner(s) that will propose a 3 years research program for developing this solution.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 1	Definition of the requirement	M2
Task 2	Trade-off: materials, manufacturing processes and qualification test method	M12
Task 3	Manufacturing and characterization of ingredients and magnet wire	M18
Task 4	1/ Qualification of new ingredients and magnet wire alone 2/ Qualifiation on sub-assembly samples	M36
Task 5	Characterization and testing of final 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, atmosphere
- Material resistance according to RTCA/DO-160…
- Electrical constraints,
- More detailed on ingredients function

Task 2: Trade-off

This trade off should be made on :

- **Materials :** list of ingredients compliant with the requirements defined in task 1,
- **Manufacturing processes.** According to the ingredient choice and the Topic manager part design different manufacturing processes could be proposed.
- **Qualification test method:** A list of test on sample and on a final products shall be proposed for the qualification of new ingredients. The standard test adapted on the high temperature could be used.

At the end of this trade-off, ingredients, manufacturing processes, qualification test method that will be used during the project will be chosen with the Topic manager. Several materials, manufacturing processes should be investigated. Criteria that will be used for the choise will be compliancy with requirements defined in task 1, cost and process maturity.

Task 3: Manufacturing and characterization of ingredients and magnet wire

The ingredients design will be defined with the Topic manager and will be manufactured according to the choices done in task 2. Several solutions will be investigated.

Characterizations will be proposed to check that the manufactured specimens are compliant with the requirements defined in task 1.

On this step, an applicant (magnet wire manufacturer) will also produce magnet wire with new ingredients. Some sample of different diameter will be manufactured.

An applicant (winding manufacturer) will be checked the impregnating varnishes on sample and the potting ingredients on sample.

When the process will be secured and optimized, the applicant will manufacture some sample per selected solutions.

The applicant will demonstrate its capacity to transfer the process to an industrial scale and to ensure aeronautical production rates. An economic analysis will be done by the applicant.

According to the results, 2 or 3 solutions will be selected for task 4.

Task 4: Qualification of ingredients, magnet wires and sub-assemblies

4.1/ Based on the qualification test method agreed in task 2, the material choosen in task 3 shall be qualified alone (magnet wire, impregnating varnishes, potting ingredient).

4.2/ According to the qualification material results, the good materials and solution shall be qualified on sub-assemblies and complete parts.

The sub-assembly could be:
- Magnet wire + impregnating varnish parts (twisted pairs…),
- Potting ingredient + plate (aluminium and steel)
- Magnet wire + impregnating varnish+ potting ingredient

Task 5: Characterization and testing of final demonstrators

The final demonstrators could be a coil in a body and the both shall be glued with the potting ingredient. The design shall be validated by the Topic manager.

The new magnet wire and ingredients qualified will be integrated in these final demonstrators.

The applicant will produce and check the quality of these demonstrators.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D0	Minutes of KOM	R	M0
D1	Definition of requirements	R	M2
D2	Trade-off	R	M12
D3	Manufacturing and characterization of ingredients and magnet wire	R + S	M24
D4	Qualification of ingredients, magnet wires	R + D	M30
D5	Qualification of sub-assemblies	R + D	M36
D5	Characterization and testing of final demonstrators	R	M36

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Trade-off	Milestone	M12

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 (varnishes, resin…)
- Extensive experience and strong knowledge on magnet wire.manufacturing.
- Extensive experience and strong knowledge on winding wire.manufacturing.
- Extensive experience and capabilities for characterisations of ingredients and for qualification of electrical insulation ingredients based on standard method.
- Facilities for implementing the processes in an industrial scale and ensuring aeronautical production rates.

IX. Model-Based identification and assessment of aircraft electrical and thermal loads architecture management functions

Type of action (RIA or IA)	RIA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP 6		
Indicative Funding Topic Value (in k€)	900 k€		
Duration of the action (in Months)	48 months	**Indicative Start Date**[61]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-SYS-02-21	**Model-Based identification and assessment of aircraft electrical and thermal loads architecture management functions**
Short description (3 lines)	
The foreseen work shall research the development of model-based algorithms, further denoted as Energy Management Functions (EMF), for the energy management of the electrical and thermal systems on aircraft level.	

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

1. Background

Current aircraft systems are mainly controlled to ensure a safe and reliable system operation. Systems and sub-systems are controlled locally, ensuring that each sub-system operates within its allowed boundaries but not allowing for energy optimal operation of systems.

The introduction of global management functions for the electrical system and the major consumer systems will enable energy efficient operation of large passenger aircraft systems, leading to a reduction of fuel burn. Combining management function on (electrical) energy generation and distribution side with major consumers will provide an additional degree of freedom for efficient system operation. Furthermore optimized handling of peak loads by those management functions will allow downsizing of systems, resulting in weight reduction on aircraft level.

2. Scope of work

A model based approach for assessment of large passenger aircraft systems architectures and their related management functions shall be applied.

Models from CleanSky1 should be reused and adapted as appropriate. In CleanSky 1 a Thermal Management System (TMF) for several system functions of electrical system architectures has been modelled and developped up to TRL3 in order to minimize thermal peak loads and optimize cooling system architecture/functionality/performance. The associated TMF use case shall be implemented into the existing energy systems design process model. Missing bricks to evaluate system performance on aircraft level shall be developed. Methods to assess and optimize the management functions on aircraft level shall be applied and where not available, shall be developed. For optimized architectures and their related management functions the benefits with respect to fuel burn reduction and weight saving shall be demonstrated by simulation for electrical generation and distribution system, for the major consumer systems and the combination of both.

Based on the optimal solutions found by simulation, support shall be provided by a rapid prototyping approach, to demonstration activities which will be conducted on airframer owned large scale test rigs (AVANT, PROVEN) including the combined management functions.

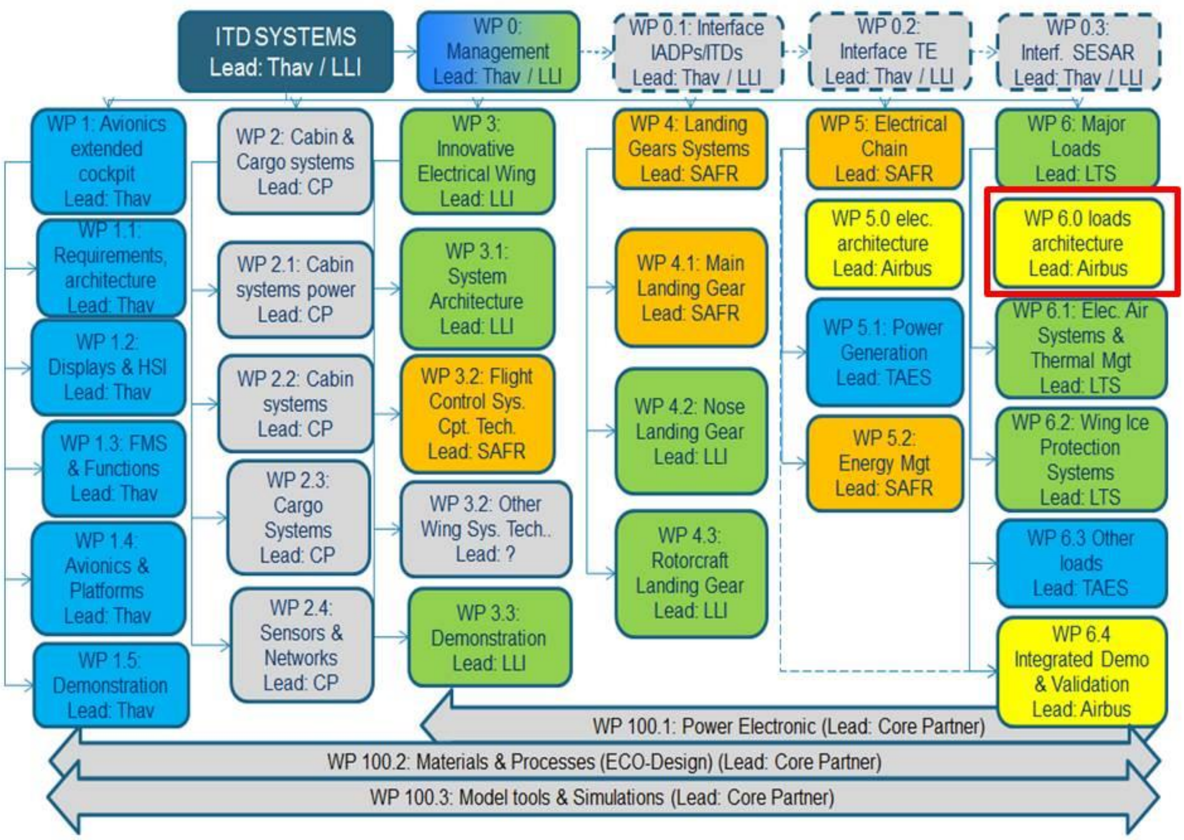
The demonstration will be undertaken within the WP 6.4, out of this call.

The target is to achieve a TRL5 for the Energy Management function at the end of the project, and the applicant support is expected up to this end.

In addition, support for integration of the final management functions shall be provided to allow demonstration up to a potential flight test not part of the project.

Large passenger aircraft electrical and thermal loads architectures and their global management functions shall be identified and assessed within WP6.0 based upon airframer input. The architectures and the management functions shall be demonstrated on large scale test rigs within WP6.4. In particular architectures and management functions for

a) the thermal management
b) the electrical management
c) a combined thermal and electrical management are foreseen.



The partner shall manage three major tasks within this CfP:

- Energy Management Functions for Electrical Systems
- Energy Management Functions for Thermal System
- Energy Management Functions for Combined Thermal and Electrical Systems

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T_6.0.1.1	Energy Management Functions for Electrical Systems	T0+36 months
T_6.0.1.2	Energy Management Functions for Thermal System	T0+36 months
T_6.0.1.3	Energy Management Functions for Combined Thermal and Electrical Systems	T0+48 months

T 6.0.1.1: The electrical power management function shall include the following activities

- Adapt the retrieved CS1 models if needed, according the reference architecture provided by the airframer
- Engineer, simulate and optimize the Electrical energy management function:
    - Optimization of overall energy efficiency
    - Exploitation of dynamic effects to further reduce power peaks without reducing availability of electrical loads
    - Manage load shedding and reduction
    - Support the system sizing of electrical system regarding realistic load profiles (i.e. reducing weight)
- Deliver energy management function source code
- Support integration and tests in Airbus ground tests rig

T6.0.1.2: The thermal management function shall include the following Tasks*

- Adapt the retrieved CS1 models if needed, according the reference architecture provided by the airframer
- Engineer, simulate and optimize the thermal energy management function:
    - Optimization of cooling split and control signals to minimize electrical power offtake and induced drag by the ram air channels to gain the minimal relative fuel consumption for these systems
    - Manage shedding and reduction of thermal loads to reduce sizing of thermal system
    - Exploitation of cabin dynamics
    - Investigate impact of forecast data from mission management to increase efficiency or cabin comfort (i.e. minimize ΔTCabin)
- Deliver energy management function source code
- Support integration and tests in Airbus ground tests rig

*Modelica shall be used

T6.0.1.3: Conduct research on combined electrical and thermal management functions. The following points shall be investigated

- Electrical and thermal models interdependency shall be identified and characterized: e.g. Cooling systems consume electrical power and will hence increase cooling demand by themselves….
- Adapt the retrieved CS1 models if needed, according the reference architecture provided by the airframer
- Engineer, simulate and optimize the thermal energy management function:
    - Thermal Energy management function and Electrical energy management function may

shed/reduce the same electrical loads.
  - There is an optimum between electrical and thermal system by considering their control functions with respect to weight, power offtake, and induced drag (i.e. Mission Block Fuel).
- Deliver energy management function source code
- Support integration and tests in Airbus ground tests rig

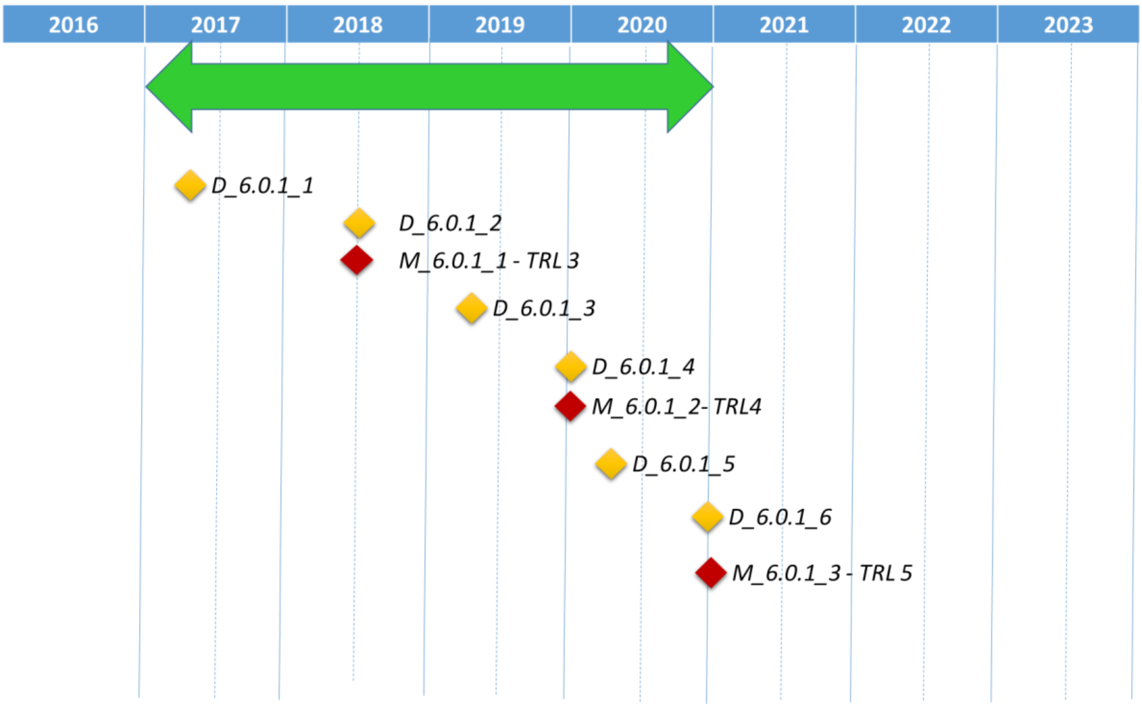
3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D_6.0.1_1	Specification of Requirement for Electrical and Thermal Management (T1,T2,T3)	R	T0+4 months
D_6.0.1_2	Demonstration of energy management functions in simulation environment (T1,T2)	R	T0+18 months
D_6.0.1_3	EMF implemented on Rapid Prototype Hardware (T1,T2, T3)	D	T0+28 months
D_6.0.1_4	Demonstration of energy management functions on rapid prototyping hardware (real-time capability) (T1,T2,T3)	R	T0+36 months
D_6.0.1_5	Planning document for support activities on ground test rigs. Specification of Software and HiL tests.	R	T0+40 months
D_6.0.1_6	Support for demonstration on ground test rigs. (T1,T2,T3)	R	T0+48 months

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M_6.0.1_1	TRL3 for EMF	RM	T0+18 months
M_6.0.1_2	TRL4 for EMF	RM	To+36 months
M_6.0.1_3	TRL5 for EMF (supporting action for Leading Partner)	RM	T0+48 months

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

Indicative Schedule:



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

- ✓ Proven expertise in the model-based software development of energy management functions
- ✓ High expertise in the development of control methods and algorithms.
- ✓ Proven know-how in the system modelling of environmental control systems for aircraft (incl. air cycles, vapor cycles, cooling loops, ram-air channel, skin-heat exchangers, etc.)
- ✓ Proven knowledge base of electrical and thermal load profiles as well as mission operations of large aircraft.
- ✓ Proven know-how in the system modelling of electrical architecture models for aircraft.
- ✓ System models shall contain impact on aircraft level performance factors.
- ✓ Proven expertise in MODELICA in order to handle existing model basis from Aircraft.
- ✓ High expertise in the field of flight performance computation for the determination of trade factors.
- ✓ High expertise in the field of multi-objective optimization.
- ✓ Knowledge of the development process of large aircraft energy systems, in order to ensure a proper achievement of TRL5.

IP management
The Energy Management Functions source code shall be owned jointly by Airbus and the applicant.

5. Abbreviations

TMF	- Thermal Management Function
EMF	- Energy Management Function
TRL	- Technology Readiness Level
HiL	- Hardware in the Loop

X. Low Power De-Icing System suitable for Small Aircrafts

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP 7.2		
Indicative Funding Topic Value (in k€)	1200 k€		
Duration of the action (in Months)	36 months	**Indicative Start Date**[62]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-SYS-03-04	**Low Power De-Icing System suitable for Small Aircrafts**
Short description (3 lines)	
To Design, Manufacture and Test up to TRL 5 a Low Power De-Icing System suitable for Small Aircraft applications. A mixed solution Electro-Thermal and Electro–Expulsive is preferred. The idea is to design the system on the icing requirement of a modified P180 aircraft Main Wing and test a section of the Main Wing Leading edge in an IWT.	

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

1. Background

As a matter of fact the small aircrafts suffer of power availability for onboard systems application. This is more and more true if small aircrafts have to be used for special missions as private interests zones Aerial Survey, Rescue, Air Ambulance; limiting their use for this kind of missions.
Aircraft De-Icing System is one of the most power demanding onboard systems and for this reason small aircrafts are sometimes limited in icing operation.
In recent years some new technologies have been introduced in the aerospace market by a US company which has researched, developed and tested the low power electro-expulsive technology for de-icing application. These technologies developed by US companies have limited application and sometimes are covered by not to export US laws.
In Europe some effort has been put in place by Clean Sky 1 to research the application of a mixed low power de-icing system (electro-thermal / electro-expulsive) but the level of size, power and weight is more for commercial aircraft application and not for small aircraft market where these constrains are much more stringent.
All the above put the need for small aircraft European manufacturer to have a safe and reliable low power de-icing system not using pneumatic source that sometimes is not available in small engine piston power plant or turboprop.
The intent of this call is to push the European aircraft systems supply chain to research, design, develop and test up to TRL 5 a low power energy de-icing system suitable in terms of power, weight, space envelope and cost for the European small aircraft transportation.
Low Power De-Icing System suitable for Small Aircrafts is part of the WP7 which is dedicated to the Small Air Transport activities, and in details is part of WP7.2 More Electrical SAT, as shown in

.
The objectives of this are therefore:

- To optimize a low power system architecture suitable for SAT.
- To develop novel integration concepts of the wing ice protection system within an small leading edge structure to optimize weight saving while ensuring manufacturing quality, reparability and maintainability.
- To demonstrate maturity of the technologies at TRL 5 level through demonstrations in representative environment
- To address integration of the proposed low power ice protection system architecture into a future longer span wing (20 m).

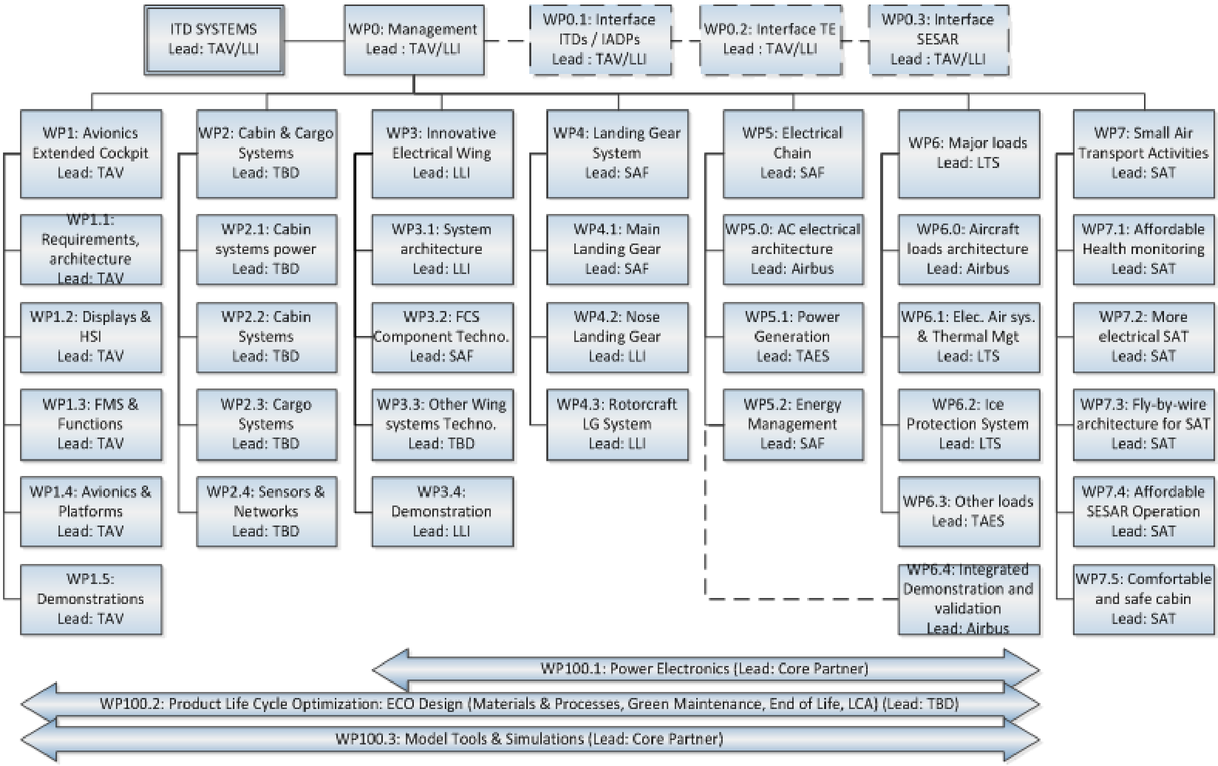


Figure 1 – WBS

2. Scope of work

The intent of this call is to select a Partner for the Design, Development and Testing in a IWT of a mixed low power de-icing system (Electro-Thermal/ Electro-Expulsive).

The scope of the activity is to design a low power de-icing system suitable for SAT.

The overall objective is to replace the present P180 Main Wing Pneumatic Ice Protection System with a low Power De-Icing System. The preferred solution shall be a mixed technology low power de – icing system (Electro – Thermal / Electro – Expulsive) completely integrated into the leading edge structure. The target wing is the present P180 Aircraft wing with a span of 14mt. The selected Partner shall address within the scope of work also a feasibility analysis to integrate the proposed low power ice protection architecture on a modified wing of the P180 aircraft with a longer span (around 20 mt).
Starting from the High Level Technical Requirements defined by the Topic Manager, the Partner shall be in charge of the system preliminary design and detailed design (including icing, thermal analysis and leading edge structure design) but also of the prototype and tooling manufacturing, and of the IWT test facility choice and IWT running. The selected Partner will work in close conjunction with the Topic Manager.

The project will be divided in the following tasks and milestone:

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T01	Ice Impingement Analysis The Partner shall provide the Ice Impingement and Ice Shapes Analysis based on the Design points and the Main Wing Leading edge characteristics provided by the Topic Manager. The choice of performing a 2D or 3D analysis is left to the selected Partner based on its experience on icing analysis. This task shall enable to demonstrate the capabilities of evaluating wing ice protection system performances in CS Appendix C, for de-icing operating modes. Specific phenomena linked to Appendix C conditions shall be analyzed and taken into consideration to define areas to be protected and electrical power required. Validation of numerical models shall be done using icing wind tunnel test results. All results of the analysis shall be put together through a report. The main activity foreseen by this task is: • Initial ice impingement and & shapes analysis for low power ice protection system requirements definition	T0+3
T02	Power budget and System Preliminary Design Based on the Ice Impingement and analysis the partner shall perform a preliminary analysis of the necessary power. Furthermore the Partner shall perform the preliminary design of the low power de-icing system based on the requirements set by the Topic Manager in the HLTR, defining the systems architecture, the LRUs and all the necessary components, the systems shall be capable of operating with an AC 115 V power distribution system. In order to optimize weight and cost, ice protection devices shall be incorporated in the wing leading edge structure made from metallic and/or composite materials within the scope of the work. The integration shall account for the interaction between the system and the structure (thermal fatigue, thermal differential expansion, mechanical fatigue, transient temperature mapping, ageing of the materials due to system operation). Furthermore, the concept shall address reparability and maintainability keeping in mind that the target is to propose solutions at least as convenient as presently in-service systems & structure. Demonstration of leading edge integrity shall be provided by analysis (Finite Element Modeling & stressing) and reduced scale testing, addressing all kinds of stresses as mechanical (static, fatigue, damage tolerance…), electrical (lightning strike,…) and environmental including bird impact and other lower energy impacts (hail, accidental damages…). Some of the activities foreseen by this task are: • Select the most suitable system architecture for a mixed de-icing system (electro-thermal/electro-expulsive), including the leading edge structure definition (composite or metallic).	T0+9

Tasks		
Ref. No.	***Title - Description***	***Due Date***
	• FEA Analysis • Preliminary thermal analysis • Select the system architecture and identify the LRUs • Identify all the interfaces (ICD) • Perform the weight assessment • Perform a space envelope assessment of the LRUs (3D models) • Perform the Electrical Power Budget • Perform the System Safety Analysis (FMEA/SSA) • Perform the residual ice analysis This Task ends with the PDR	
T03	<u>System Detailed Design</u> The Partner shall perform the Detailed Design of the Low Power De-Icing System. In particular shall: • Perform the detailed design of all the system components/equipments. • Provide detailed 2D drawings of all the components/equipments. • Updated Weight Report • Finalize the Power & Electrical Load Analysis • Perform manufacturing tooling drawings. • Provide a preliminary reduced scale IWT Plan & Procedure • Test Rig Mechanical design This Task ends with the CDR	T0+18
T04	<u>Prototype Manufacturing and IWT readiness</u> The Partner shall be responsible for the System Prototype manufacturing and for the definition of the reduced scale IWT planning and Procedure to demonstrate the effectiveness of the Low Power De-Icing System. The Partner Shall Provide IWT test facility and Test Instrumentation as well. In particular shall: • Test Rig Mechanical Manufacturing • Manufacture the necessary tooling • Manufacture the System Prototype for the IWT • Test Rig for Ice wind tunnel tests - Aerodynamic design (reduced P180 wing with flap) • Provide detailed Planning and Procedures for the IWT. • IWT instrumentation specification This Task ends with the TRR	T0+26
T05	<u>Validation trough testing (reduced scale IWT Running)</u>	T0+30

Tasks		
Ref. No.	***Title - Description***	***Due Date***
	The Partner shall be responsible for running the reduced scale IWT on the Prototype System for performance demonstration at the agreed Design Points with the Topic Manager. On the other hand, endurance testing has to be achieved to get data about new design of ice protection devices. Maturity of the proposed concept, which is one of the main drivers, has to be shown. Finally, environmental test campaign of the systems LRUs shall be performed to demonstrate adequate design through operating conditions. In this task the partner shall be responsible for (but not only): • Installing the Prototype and Instrumentation in the IWT. • Run the IWT and record all the data • Write the IWT report • Run Environmental/Endurance Tests & write reports	
T06	System growth capability for longer span wing (up to 30 mt) This task shall address the low power ice protection system in the context of a longer span wing application. Conceptual studies shall be performed to ensure that the selected system architecture can be easily scaled on longer span wing. The study has to be supported by performances calculations & design studies addressing specifically the power budget topic. Demonstrations shall be conducted to demonstrate TRL3 maturity.	T0+30

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Icing Impingement and Ice Shapes Analysis	R	T0+3
D2	Preliminary System Specification including performance numerical code validation justification	R	T0+9
D3	System ICD	R	T0+12
D4	Weight Report	R	T0+12
D5	Preliminary Electrical Power budget	R	T0+12
D6	LRUs 3D models	D	T0+12
D7	FEA Analysis (structural integration demonstration)	R	T0+12
D8	FMEA & SSA	R	T0+12
D9	Residual Ice shapes Analysis	R	T0+12
D10	System Final Specification	R	T0+24

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D11	Components/Equipments 2D Drawings	D	T0+24
D12	Final Electrical Power Budget	R	T0+24
D13	Tooling Drawings	D	T0+24
D14	Updated Weight Report	R	T0+24
D15	IWT preliminary Planning and Procedure	R	T0+24
D16	Test Rig Drawings (3D & 2D)	D	T0+24
D17	System Prototype Hardware to support test campaigns (System LRUs + Leading edge structure)	D	T0+32
D18	Test Rig & Tooling availability	D	T0+32
D19	IWT instrumentation	D	T0+32
D20	IWT Planning and Procedure	R	T0+33
D21	IWT Report	R	T0+36
D22	Environmental & Endurance Tests report	R	T0+36
D23	Concept & system performances study on ice protection for longer span wing.	R	T0+36

Note on hardware deliverables:

- The Partner is expected to deliver all hardware and instrumentation necessary for the demonstrations planned in T01 to T06
- In particular, the Partner shall be in charge of a reduced scale IWT campaigns for performance demonstration purpose (with dedicated hardware deliveries) on a section of P180 Main Wing leading edge with integrated the low power ice protection system.
- Dedicated demonstrations have to be addressed for others topics (Environmental, endurance tastings to be achieved to get data about new design of ice protection devices.
- It is not expected to perform flight tests as part of the project. However, a prototype low power ice protection system compliant with performance and operational requirements shall be provided by the partner, in order for the Topic Manager to easily and quickly get through future steps an airworthy system with complete Safety of flight justification.

Milestones (when appropriate)

Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Ice Impingement and Ice Shapes Report	R	T0+3
M2	PDR	DR	T0+12
M3	CDR	DR	T0+24
M4	Prototype System, Test Rig & Tooling Delivery for IWT	D	T0+32
M5	TRR	DR	T0+33
M6	IWT & Test campaign reports	R	T0+36

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

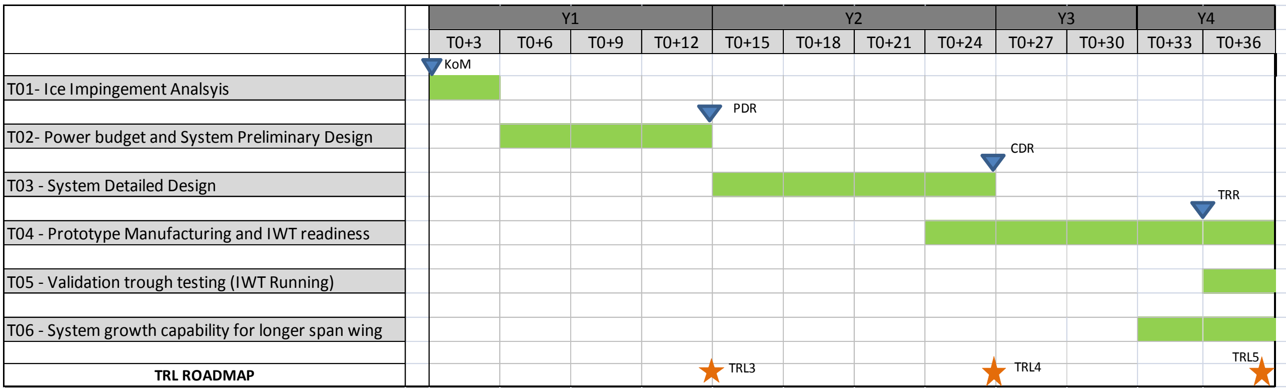


Figure 2 – Schedule

4. <u>Special skills, Capabilities, Certification expected from the Applicant(s)</u>

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.
- Proven experience in Ice Impingement and Ice shapes analysis (both 2D and 3D).
- Numerical tools availability to assess thermal performances in Appendix C conditions.
- Numerical tools availability to assess 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 design experience
- Proven IWT test running experience.
- Instrumentation data acquisition, recording and monitoring.

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

HLTR

A set of High Level Technical Requirements (HLTR) for the 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

A/C	Aircraft
FH	Flight Hours
FMECA	Failure Mode, Effects and Criticality Analysis
ICD	Interface Control Document
I/O	Input /Output
LRU	Line Replaceable Unit
KoM	Kick of Meeting
PDR	Preliminary Design Review
CDR	Critical Design Review
TRR	Test Readiness Review
HLTR	High level Technical Requirements
IWT	Ice Wind Tunnel
SAT	Small Aircrafts Transportation
FEA	Finite Element Analysis
R&T	Research and Technology
FMEA	Failure Mode & Effect Analysis
SSA	System Safety Analysis
AC	Alternate Current

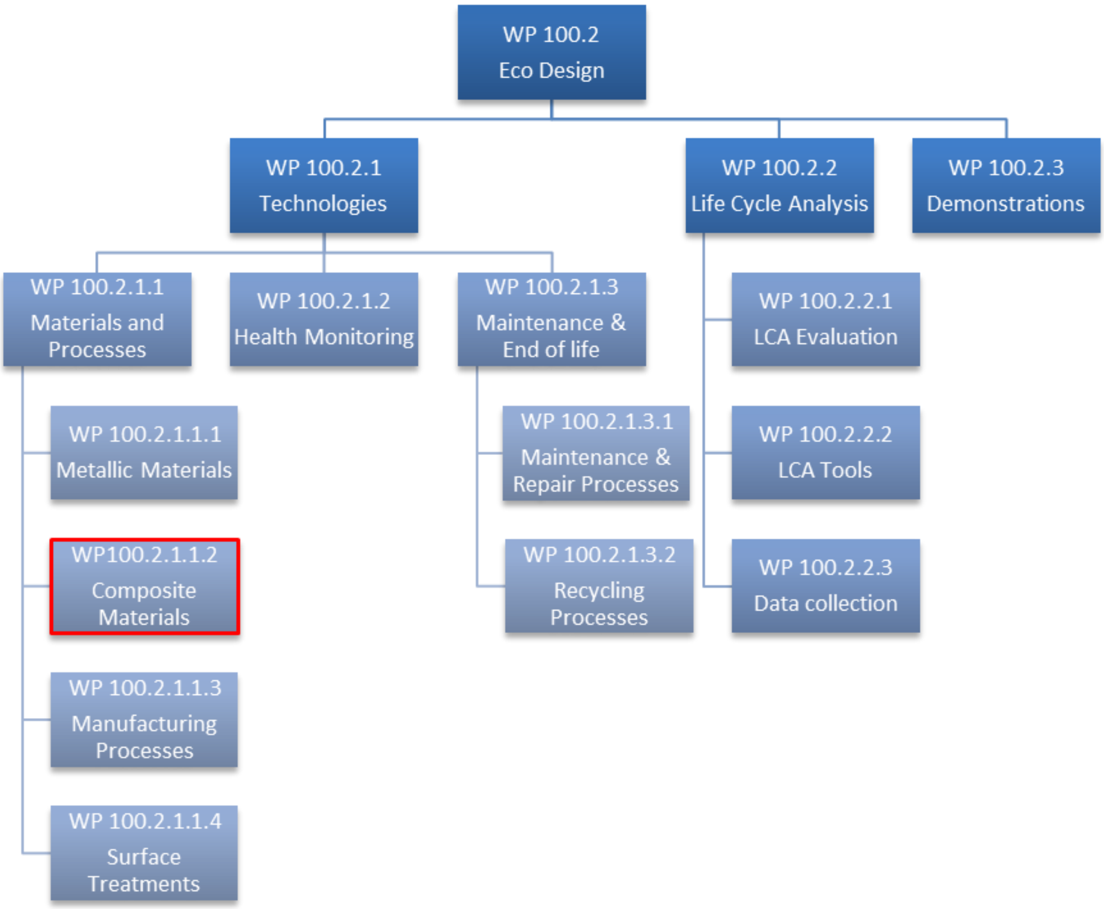
XI. Eco Design: High efficient non-structural landing gear parts based on advanced carbon fiber material systems and highly automated production technologies for helicopter and aircrafts

Type of action (RIA or IA)	IA		
Programme Area	SYS [ECO]		
Joint Technical Programme (JTP) Ref.	WP 100.2		
Indicative Funding Topic Value (in k€)	400 k€		
Duration of the action (in Months)	30 months	**Indicative Start Date**[63]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-SYS-03-05	**Eco Design: High efficient non-structural landing gear parts based on advanced carbon fiber material systems and highly automated production technologies for helicopter and aircrafts**
Short description (3 lines)	
The work of the partner is to develop, manufacture and test high efficient none-structural landing gear parts for helicopter and aircrafts based on advanced carbon fiber material systems and highly automated production technologies considering lightweight construction principles, dedicated certification strategies and overall cost of ownership. The aim of the project is to develop, manufacture and lab-/ or, and flight test this equipment in relevant environment.	

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

1. **Background**



The objective of the WP100.2.1.1.2 is the development of new innovative and high efficient composite parts, in particular non-structural landing gear parts for helicopter and aircrafts based on advanced carbon fiber material systems and highly automated production technologies considering lightweight construction principles, dedicated certification strategies and overall cost of ownership.

Composite parts are well established in many industries but still rare in aircraft landing gear applications. For helicopters and aircrafts the composite technology gets more and more interesting due to the achievable weight saving and cost potentials by improvements in material systems (fiber and matrix), analysis methods and highly automated production technology.

Today's non-structural landing gear parts are based on state of the art materials such as aluminum, stainless steel or titanium based on bar, casting or sheet metal material. Using these materials either a limited weight saving is achieved or high manufacturing cost and/or material cost have to be considered. Special care for corrosion protection is necessary to be compliant with todays and future aircraft and REACH requirements.

The goal of this topic is to establish the basis for the development and manufacturing of high efficient non-structural landing gear parts made out of composites (long / short fiber), to save weight and improve cost of ownership in comparison with current isotropic material applications. The main focus shall be made firstly on parts such as MLG and NLG door rods (mainly tension and compression loads) and secondly on their links and attachment brackets in general.

The parts shall be developed by the potential partner in full compliance to the high level requirements of typical helicopter and aircraft application, these requirements are but not limited to:

- Interfaces and maximum design envelop
- Complete load set as ground, landing, flight and vibration loads
- Natural frequencies and stiffness
- Environmental conditions as high/low temperature, moisture, fluid susceptibility and ultra violet radiation
- Sustainability to impact strength as particular risk scenarios, hail, FOD and bench handling
- Other not yet defined requirements for composite parts in aircraft applications.

Furthermore the developed parts must have an overall benefit in weight and cost to current aluminum, steel and titanium applications.

The potential Partner to be assigned for this work package shall preferably be already experienced and established in the aeronautical business devoted to composite development, design or/and manufacturing. The potential Partner mandatorily needs to be already established in the industrial/automotive composite component segment and shall be proficient with the challenge of the development of composite parts used in harsh environments.

Funded knowledge in the development of composites for landing gear applications up to a maturity level of demonstration flight shall preferably belong already to the Core Partner’s portfolio.

The first steps will focus mainly on trading today´s available composite technologies and identify potentially new technologies e.g. advanced matrix systems, preform methods and high automated manufacturing technologies to support and assure production robustness, decrease cutting losses and scrap rate including strategies for improved fiber strength utilization and state of the art manufacturing. The Topic Manager does see the adequate production method as mandatorily to assure the later robust serial production and high quality target.

Specific competence need to be a section of partner's portfolio on which fiber, fabric and matrix system combination results in dedicated material allowable. Furthermore the potential partner shall have competence on various manufacturing technologies, preferably based on own manufacturing facilities. The knowledge for the whole production chain/process shall be either available at the Partner itself or via a third tier supplier who is well known by the Partner.

Moreover efficient design, analysis and simulation methodology has to be subject of the development. Proven experience in numerical analysis methods and process simulations of composite materials to predict mechanical behavior and in actual and new certification strategies of composite aircraft structures is seen as advantageous to fulfill the Topic Managers weight reduction target.

Beside the functional and performance requirements the cost and reliability values need to be in a competitive range to the market. Cost of ownership and maintenance intervals of composite landing gear parts shall be at least equal or better than today's solution on the market.

The challenging aspects of the WP are:

- Operating and environmental and conditions, such as
    - Safety criticality
    - Ambient temperature (-55 °C … +80 °C for braces, … up to + 220°C for Major Structural Parts)
    - Impact resistance for different impact scenarios during in service as take-off, flight, landing and transportation/handling
    - Demanding environmental levels
    - High number of duty cycles (> 100.000 flight cycles)
    - Test the parts under harsh environment and conditions
- Aerospace approved materials and processes
- Aerospace requirements

The identified concepts shall be elaborated analyzed and evaluated. Retrofit solutions shall be considered.

The function and applicability of the developed technologies shall be proven by test. Therefore corresponding functional demonstrators have to be provided in attunement with Topic Manager.
Topic Manager will provide the top level requirement for the high efficient composite parts. The partner is in charge for engineering, manufacturing and to provide the test facility, executes the tests and the documentation of the test results.
The demonstration phase will principally consist of functional and performance tests including vibration and high/low temperature testing. In addition it is conceivable to conduct accelerated tests.
The Partner has to clearly depict details of test campaign (type of test, when, where, etc.) prior to test launch.

Note: Specifications for the high efficient composite parts will be provided by Topic Manager once the partner has been selected after signature of a Non-Disclosure Agreement (NDA) between the two companies.
In case of assignment of a third tier supplier by the Partner the Topic Manager will be open for conveyance of

such a consortium.

This call for proposal is a scientific and industrial challenge and provides opportunity of competitiveness on improvement of costs, manufacturing and economy of parts used in e.g. landing gear applications for European partners of Clean Sky.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T01	State of the Art Analysis – Analysis of today's available composite technologies and identification of potentially new technologies e.g. advanced matrix systems, preform methods and high automated manufacturing technologies to assure production robustness, decrease cutting losses and scrap rate including strategies for improved fiber strength utilization and state of the art manufacturing.	T0 + 3M
T02	Concept Phase – Together with Topic Manager, the partner will propose and trade design and production concepts for each application (rod, linkage and bracket). Preliminary design and stress analysis will support the evaluation. The technologies will be benchmarked with regards to weight saving potential and cost of ownership.	T0 + 5M
T03	Preliminary Design – Based on the outcome of the concept phase the partner will start to work out the agreed concepts. The selected concepts will be matured and adapted to Topic Manager part interfaces in order to fit the demonstration platform of Clean Sky 2. The weight saving and cost of ownership will be estimated and matched with market expectations.	T0 + 10M
T04	Detail Design – The preliminary design will be analyzed in detail in regards to function and stress. The outcome shall be then designed in accordance to the demonstration foreseen and proposed for prototyping approval. In parallel the partner shall propose an adequate test campaign to demonstrate major functions and strength parameter.	T0 + 16M
T05	Production – The partner shall build at least the necessary full functional demonstration test hardware and one marketing mock-up.	T0 + 19M (partly parallel to T04)
T06	Test – The partner shall be responsible for: - Planning and provision of test equipment (rigs, etc.), - Execution of verification tests, - Reporting and analysis of the test results.	T0 + 28M

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T07	Certification Phase – The partner shall be responsible for: - Execution of certification tests, - Supporting the flight test campaign - Reporting and analysis of the test results.	T0 + 30M

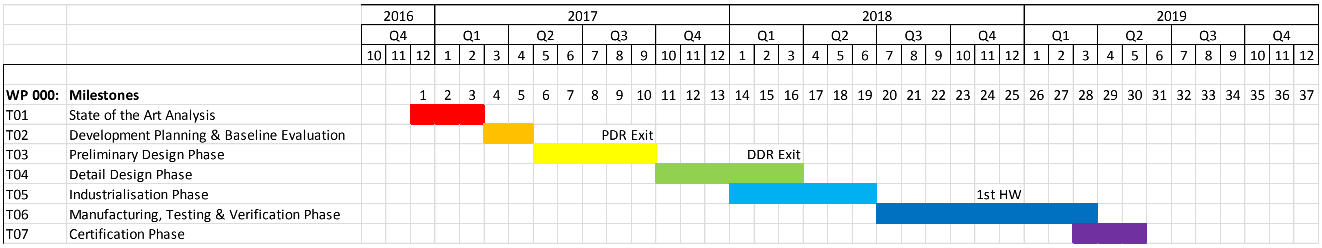
3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D01	State of the Art Analysis	R	T0 + 3M
D02	Concept Studies	R	T0 + 5M
D03	Preliminary design and analysis	R	T0 + 10M
D04	Detail design and analysis	R	T0 + 16M
D05	Production of Demonstration Hardware and Marketing Mock-Up	R	T0 + 19M
D06	Qualification Test Campaign	R	T0 + 28M
D07	Certification Test Campaign	R	T0 + 30M

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M01	Start Baseline Definition	RM	T0 + 4M
M02	Start Detail Design	RM	T0 + 11M
M03	Start Production	RM	T0 + 17M
M04	Start of Technology Demonstration	RM	T0 + 20M
M05	1st Hardware Delivery	D	T0 + 25M
M06	Start of Flight Test Campaign	RM	T0 + 28M

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



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

- ✓ Experienced and established in the aeronautical business devoted to composite development, design or/and manufacturing but mandatorily industrial/automotive background
- ✓ Specific competence on which fiber, fabric and matrix system combination results in dedicated material allowable.
- ✓ Competence of the various manufacturing technologies of composite aircraft structures, preferably own manufacturing facilities.
- ✓ Experience in numerical analysis methods and process simulations of composite materials to predict mechanical behavior.
- ✓ Knowledge in actual and new certification strategies of composite aircraft structures.
- ✓ Knowledge of aerospace environmental conditions requirements as e.g. RTCA DO-160

XII. Eco Design : 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		
Indicative Funding Topic Value (in k€)	350 k€		
Duration of the action (in Months)	18 months	**Indicative Start Date**[64]	Q1 2017

Identification	**Title**
JTI-CS2-2016-CFP03-SYS-03-06	**Eco Design: Electrocoating process for Cr6-free surface treatment of aluminium parts**
Short description (3 lines)	
This Topics aims at exploring the applicability of anaphoretic electrocoat on aircraft parts made of aluminium and its alloys. The aims are replacement of chromate–containing anodizing process, reduction of emissions, saving of coat and improvement of corrosion protection	

[64] 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 to replace the actual anodising process. It shall also enable 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 developed anaphoretic coating on aluminium shall be better than the adhesion of traditional painting system on the anodised aluminium. 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 on the mechanical properties of the ground 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 that could be adequate for the development of the anaphoretic coating process for aluminium alloys of 7000 series. After the solution screening, one or two solutions 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 electrocoating process for aluminium alloys of 7000 series shall be clearly defined 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, 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 scientific and industrial challenge providing opportunity of competitiveness on improvement of costs, ecology, manufacturing, endurance and overhaul of parts of landing gears 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	T0 + 4M
T3	Develop and optimize the anaphoretic coating process	T0 + 6M
T4	Apply 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 teste big specimens	Hardware	T0 + 17M
D6	Test results of the big specimens	Doc	T0 + 17M
D5	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.
- ✓ Good background and experience regarding the aerospace requirements.
- ✓ Good background and experience on possible tests conducted on coatings
- ✓ Facilities to conduct tests on coated specimens/parts (either directly or through a partner/subcontractor)
- ✓ Adequate equipment and facilities for the coating process to be investigated and quality control system
- ✓ Available resources to execute the respective tasks should be stated in the proposal.
- ✓ Proven capacity to manage this work in time without delay for study and development phases.