Annex III:
4th Call for Proposals (CFP04):
List and Full Description of Topics

Call Text

- 21 June 2016 -

Revision History Table		
Version n°	**Issue Date**	**Reason for change**
R4	21 June	Release for publication on Participant Portal [Call Launch]

Important notice on Q&As

Question and Answers will open as from the day of the Call Launch.

In case of questions on the Call (either administrative or technical), applicants are invited to contact the JU using the **dedicated Call functional mailbox:** Info-Call-CFP-2016-02@cleansky.eu

Note that questions received up until 16th August 2016, 17:00 will be answered after analysis and published in Q&A when appropriate. In total, three publications of Q/As are foreseen: 19th July, 11th August and 6th September 2016 (estimated dates).

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

Index

Overview of number of topics and total funding value per SPD

Area	No. of topics	Indicative Funding (in M€)
IADP Large Passenger Aircraft	13	10.60
IADP Regional Aircraft	5	3.18
IADP Fast Rotorcraft	5	3.50
ITD Airframe	15	9.80
ITD Engines	9	8.56
ITD Systems	10	12.28
TA Small Air Transport (SAT)	(2)	(2.00)
TA ECO Design 2	-	-
TA Technology Evaluator 2	-	-
TOTAL	57	47.92

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 (CFP04)

Identification Code	Title	Type of Action	Value (Funding in M€)	Topic Leader
JTI-CS2-2016-CFP04-LPA-01-18	New Acoustic Signal Processing Methods	RIA	0,350	Airbus
JTI-CS2-2016-CFP04-LPA-01-19	High fidelity Large Eddy Simulation using reduced model for engine broadband noise prediction	RIA	0,600	Airbus
JTI-CS2-2016-CFP04-LPA-01-20	Hybrid machining for high removal rates and surface integrity applicable for safety critical super alloy parts	IA	0,700	GKN
JTI-CS2-2016-CFP04-LPA-01-21	Design for High AN² (Disk and Blade attached)	IA	0,500	GE Avio
JTI-CS2-2016-CFP04-LPA-01-22	RIGHT (Rig instrumentation, test support & data analysis of High Speed Power Turbine)	IA	0,350	GE Avio
JTI-CS2-2016-CFP04-LPA-01-23	Low Cost, Smart Tooling for Composites	IA	0,500	Aernnova
JTI-CS2-2016-CFP04-LPA-01-24	High throughput micro drilling (HTMD) system	IA	2,000	Aernnova
JTI-CS2-2016-CFP04-LPA-01-25	Smart amplifier and a control box for fluidic actuators	IA	0,500	Fraunhofer
JTI-CS2-2016-CFP04-LPA-01-26	Design, Build and Test Innovative Actuation Concepts for Separation Flow Control	RIA	0,700	Airbus
JTI-CS2-2016-CFP04-LPA-01-27	Development of scaled models for Synthetic Jet Actuators based on Aerodynamic Characterization in CFD, Ground and Wind Tunnel Testing	RIA	0,600	Fraunhofer
JTI-CS2-2016-CFP04-LPA-01-28	Divergent Aircraft Configurations	RIA	1,500	Airbus (DLR / Onera)
JTI-CS2-2016-CFP04-LPA-02-15	Development of a Multi-scale method to predict large aircraft component failure taking into consideration Manufacturing Uncertainties for Predictive Virtual Simulations	RIA	0,800	Airbus
JTI-CS2-2016-CFP04-LPA-03-08	Active Cockpit Simulator/Ground Station Facility and Test Environment enhancement	IA	1,500	Airbus DS SAU
JTI-CS2-2016-CFP04-LPA		13 topics	10,600	
JTI-CS2-2016-CFP04-REG-01-05	Green Turboprop - High lift configuration integrating adaptive wing concept - Low Speed experimental validation	IA	1,200	FNM VEL
JTI-CS2-2016-CFP04-REG-01-06	High Fidelity Integrated Non-Linear MBS Modelling of Morphing Wing	RIA	0,350	FNM VEL
JTI-CS2-2016-CFP04-REG-01-07	Innovative alloy development for structural part fabrication with Additive Manufacturing Technology	IA	0,600	FNM VEL

Identification Code	Title	Type of Action	Value (Funding in M€)	Topic Leader
JTI-CS2-2016-CFP04-REG-01-08	**Advanced Energy Storage and Regeneration System for Enhanced Electrical Energy Management**	RIA	0,800	FNM VEL
JTI-CS2-2016-CFP04-REG-02-03	**Electrohydraulic integration of an hybrid surface actuation systems**	IA	0,230	Airbus DS SAU
JTI-CS2-2016-CFP04-REG		**5 topics**	**3,180**	
JTI-CS2-2016-CFP04-FRC-01-11	Hydrophobic Windscreen Protection for Next Generation Civil Tilt Rotor	IA	0,750	FNM Helicopters
JTI-CS2-2016-CFP04-FRC-01-12	Flight critical wireless slip ring for a civil tiltrotor	IA	0,750	FNM Helicopters
JTI-CS2-2016-CFP04-FRC-02-16	Bird strike - Erosion resistant and fast maintainable windshields	IA	0,600	AH
JTI-CS2-2016-CFP04-FRC-02-17	Flight management system providing noise abatement flight procedures for compound rotorcraft	IA	1,000	AH
JTI-CS2-2016-CFP04-FRC-02-18	Full Fairing for Main Rotor Head or the LifeRCraft demonstrator	IA	0,400	AH
JTI-CS2-2016-CFP04-FRC		**5 topics**	**3,500**	
JTI-CS2-2016-CFP04-AIR-01-20	**Development of a highly instrumented, modular fan module for aerodynamic and acoustic wind tunnel testing**	RIA	0,600	Airbus
JTI-CS2-2016-CFP04-AIR-01-21	**Integrated Automated Test Bench Control System with Certifiable Test Documentation Functionality**	IA	0,600	Fraunhofer
JTI-CS2-2016-CFP04-AIR-01-22	**Laminated and panoramic Cabin Windows for Business Jet applications**	IA	0,400	Dassault Aviation
JTI-CS2-2016-CFP04-AIR-01-23	**Novel manufacture of low weight skin without chemical milling**	RIA	0,900	SAAB
JTI-CS2-2016-CFP04-AIR-01-24	**Multi-functional cabin rest area**	IA	0,500	Airbus
JTI-CS2-2016-CFP04-AIR-02-28	**Development of methods for deriving optimized shapes of morphing structures considering both aerodynamic performances and specific mechanical morphing boundary conditions**	RIA	0,350	Fraunhofer
JTI-CS2-2016-CFP04-AIR-02-29	**Development and Manufacturing of Prototype metallic parts.**	IA	0,750	OUTCOME
JTI-CS2-2016-CFP04-AIR-02-30	**Development and manufacturing of innovative stamping dies for aluminium ribs Hot Stamping**	IA	0,350	OUTCOME
JTI-CS2-2016-CFP04-AIR-02-31	**Numerical methodologies and related tools for effect of defect prediction in manufacturing**	RIA	0,500	Airbus

Identification Code	Title	Type of Action	Value (Funding in M€)	Topic Leader
JTI-CS2-2016-CFP04-AIR-02-32	Testing matrix optimization by interaction between numerical modelling and innovative non-contact measurement technology	IA	0,500	Airbus
JTI-CS2-2016-CFP04-AIR-02-33	Developing innovative joining concepts and their manufacturing methodologies	IA	0,500	EVE
JTI-CS2-2016-CFP04-AIR-02-34	Hardware demonstrator development and deployment on Future Industrial Human Machine Interface (HMI) and Connected factory technologies	RIA	0,300	Airbus DS (CASA)
JTI-CS2-2016-CFP04-AIR-02-35	Development and deployment of new procedures and PLM Tools for A/C Ground Functional testing with Eco-design criteria	RIA	0,650	Airbus DS (CASA)
JTI-CS2-2016-CFP04-AIR-02-36	Development of prototype system based on Laser UT technology for high speed contactless no-couplant inspection of hybrid and thick composite structures	IA	2,500	FNM VEL
JTI-CS2-2016-CFP04-AIR-02-37	Quilted Stratum Processes (QSP) for low cost and eco thermoplastic manufacturing of complex composite parts	IA	0,400	SHERLOC
JTI-CS2-2016-CFP04-AIR	**15 topics**		**9,800**	
JTI-CS2-2016-CFP04-ENG-01-10	High speed turbine performance improvement through cascade tests	RIA	1,500	Safran
JTI-CS2-2016-CFP04-ENG-01-11	2 VBV actuators (LHS & RHS) for Ground Test Demo 2 VSV booster actuators (LHS & RHS) for Ground Test Demo	IA	1,800	Safran
JTI-CS2-2016-CFP04-ENG-01-12	Development of the investment casting process and weldability for high temperature capable superalloys	IA	0,700	GKN
JTI-CS2-2016-CFP04-ENG-01-13	High load gear and bearings materials	IA	0,450	AA
JTI-CS2-2016-CFP04-ENG-01-14	Experimental & Numerical analysis dedicated to FOD Management for Turboprop Air intake	RIA	0,950	Safran TM
JTI-CS2-2016-CFP04-ENG-02-05	Substitution of Chromium(VI)-based substances for corrosion protection of Aluminum- and Magnesium alloys	RIA	1,000	MTU
JTI-CS2-2016-CFP04-ENG-03-13	Small-Scale Spin Test for Hoop-Burst Overspeed Assessment	RIA	0,663	Rolls-Royce
JTI-CS2-2016-CFP04-ENG-03-14	Fuel injector coking	IA	1,000	Rolls-Royce
JTI-CS2-2016-CFP04-ENG-04-06	Engine Control System	IA	0,500	Safran SMA

Identification Code	Title	Type of Action	Value (Funding in M€)	Topic Leader
JTI-CS2-2016-CFP04-ENG	**9 topics**		**8,563**	
JTI-CS2-2016-CFP04-SYS-01-03	**Very high brightness & compact full color display for next generation eyes-out cockpit products**	RIA	3,800	Thales Avionics
JTI-CS2-2016-CFP04-SYS-02-22	**Validation tests of electromechanical actuators and its dedicated control units at TRL 6 level**	IA	0,732	CESA
JTI-CS2-2016-CFP04-SYS-02-23	**ECO-design based techniques and machinary for improved racking and distribution boxes manufacturing**	IA	1,000	Safran LPS
JTI-CS2-2016-CFP04-SYS-02-24	**Electrical simulation model identification method and tool**	IA	0,350	Airbus
JTI-CS2-2016-CFP04-SYS-02-25	**Innovative cooling system for embedded power electronics**	IA	0,800	Thales
JTI-CS2-2016-CFP04-SYS-02-26	**Multivariable control approach for electrical air conditioning pack**	IA	0,500	Liebherr
JTI-CS2-2016-CFP04-SYS-02-27	**Alternative recirculation filter for better cabin air quality**	IA	1,100	Liebherr
JTI-CS2-2016-CFP04-SYS-02-28	**Analysis, validation and parametric studies of design and operating parameters for modern cabin ventilation concepts related to future aircraft energy management systems**	IA	2,000	Airbus
JTI-CS2-2016-CFP04-SYS-03-07	**An innovative Electrical Power Distribution System (EPDS) for Small Aircraft**	IA	1,000	Piaggio
JTI-CS2-2016-CFP04-SYS-03-08	**Electromechanical actuation for landing gear**	RIA	1,000	Piaggio
JTI-CS2-2016-CFP04-SYS	**10 topics**		**12,282**	

1. Clean Sky 2 – Large Passenger Aircraft IAPD

I. New Acoustic Signal Processing Methods

Type of action (RIA or IA)	RIA		
Programme Area	LPA, Platform 1, WP1.1.1		
Joint Technical Programme (JTP) Ref.	JTP_v5		
Indicative Funding Topic Value (in k€)	350 k€	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36 months	**Indicative Start Date**[1]	Q2/2017

Topic Identification Code	Title
JTI-CS2-2016-CFP04-LPA-01-18	New Acoustic Signal Processing Methods

Short description

The future engine architecture (UHBR or CROR) will be less and less noisier and it will become difficult to extract from acoustic signal measured by one or several microphones the acoustic contribution from turbulent boundary layer for example. Unfortunately, current state-of-the-art signal processing methods are not mature enough to be able to de-noise and extract accurately both tonal and broadband noise part and to separate accordingly the contribution of different sources. Three main axis will be explored:

1. Aeroacoustics sources separation by the use of spatial filtering
2. De-noising by the use of cyclostationarity
3. Acoustic sources localization by the use of Baysian approach.

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

1. Background

Currently, Airbus is dealing with both wind tunnel test and flight tests. In this frame, microphones are installed on the fuselage or on a specific microphone support in the flow (see Figure 2). In both cases, microphones measurements are polluted by turbulent boundary layer (see Figure 1). On very low thrust configuration, the signal-to-noise ratio is very poor.

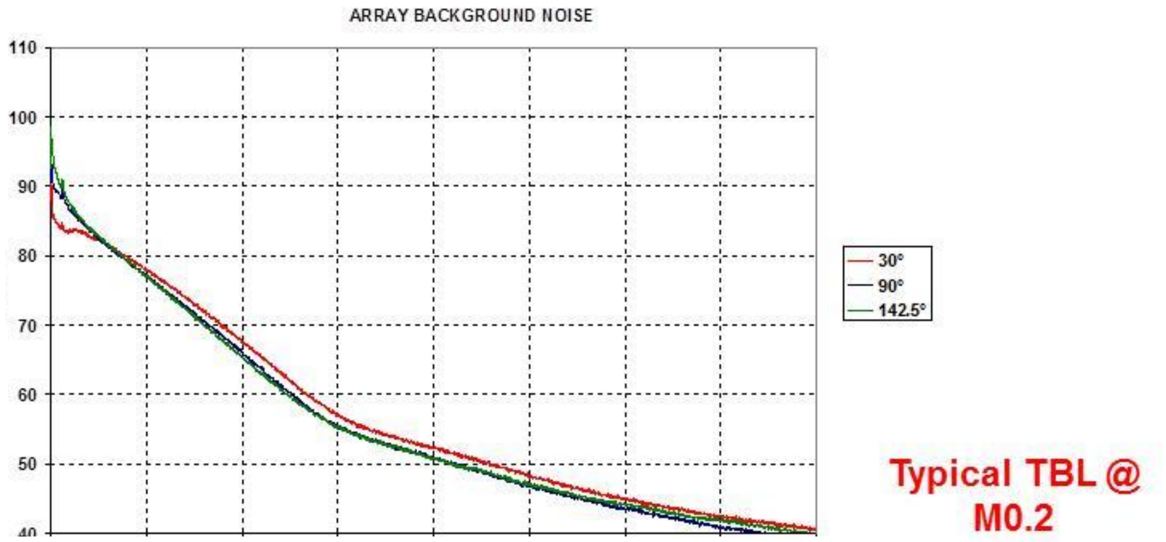

Figure 1 - Typical example of turbulent boundary layer

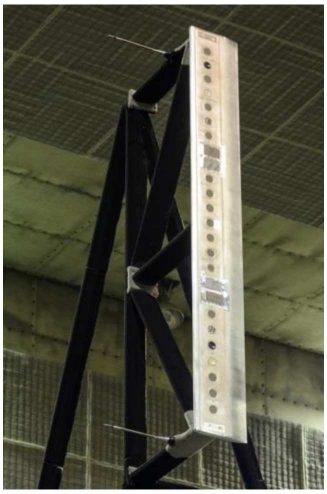

Figure 2 - Typical instrumentation in the flow.

Future engine architecture (UHBR or CROR) will be less and less noisier and it will become more and more difficult to extract from measured signals the acoustic component and the right component extraction by the use of one or several microphones the acoustic contribution from turbulent boundary layer for example.

The objective of this topic is therefore to explore, develop and validate three main approaches which could help to de-noise and separate accurately acoustic sources from a typical measurement coming from flight and/or wind tunnel test.

2. Scope of work

Airbus will provide all necessary test data (from wind tunnel & flight test) to support activities of the work packages described below.

WP 1: Aeroacoustic source separation: in particular the extraction of acoustic component from hydrodynamic component but also the different acoustic component.

A major issue of in-flow acoustic measurements concerns the separation between the pressure fluctuations induced by the turbulence from the acoustic waves actually emitted by the sources. These two components are characterized by very different spatial structures, which allow separating them using, for example, parietal microphone array measurements.
In the frame of this work-package, the partner is expected to explore two main approaches. The criteria to validate the methods and the limits to be checked will be discussed with Airbus at the beginning of the project.

WP1.1: Extraction of acoustic component from hydrodynamic by the use of stochastic modelling.
Based on stochastic modelling and taking into consideration that the latter has a much shorter correlation length than the former, a separation is then theoretically possible by representation of the measurement by a superposition of two Gaussian processes with covariance matrices parameterized with different scale lengths. This result is a highly nonlinear identification problem and could be solved within a Bayesian framework, in particular by using Monte Carlo Markov Chain algorithms. The partner will develop, assess (by the use of simulation and real data) and validate this approach (including the identification of the gain and the limits of this approach). At the end, the algorithm will be explained and delivered to Airbus with appropriate test cases.

WP1.2: Extraction of acoustic component from hydrodynamic by the use of structural vibration measurements.
Another promising approach could be based on acceleration measurements on a structure inside the flow, taking advantage of the spatial filtering effect of the structure, it would be thus pertinent to associate acoustic and vibration measurement to achieve and improve the separation. The partner will develop, assess (by the use of simulation and real data) and validate this approach (including the identification of the gain and the limits of this approach). Moreover, a dedicated test will be put in place in order to demonstrate the technology.

WP2: De-noising techniques based on cyclostationarity in order to improve data analysis.

Rotating machines are prone to produce noise sources with very specific statistical properties. A quite general way of describing them is by means of cyclo-stationary stochastic processes, whose statistics are periodically time-varying. The class of cyclo-stationary processes includes tonal noise and broadband stationary noise as

particular cases, but also comprises non-stationary phenomena that results from amplitude and frequency modulations such as impinged by rotating rotors.
This formalism is not only useful to describe quite generally, in a phenomenological way, the acoustical field generated by rotating machines, but is also offering numerous perspectives for processing the signals.

One major perspective of cyclo-stationary processing is to allow the decomposition of the signal into its various constituents such as tonal noise, broadband noise due to rotating of the stator and/or propeller and stationary background noise. Sources of noise – either tonal or broadband – originating from different rotating components can also be separated on this basis. This allows the independent analysis of sources of noise and their ranking in a way that could hardly be achieved otherwise, at least without the use of complicated experimental apparatuses. A specific source of noise can thus be extracted from the measurements and investigated finely as if it was measured alone with all other interfering sources of noise switched off.

WP2.1: Cyclo-stationarity proof of concept.
Another perspective of the approach is to de-noise a set of measurements by retaining only the components that are synchronously coherent with one rotating component in the machine. This is most useful for subsequent acoustical imaging and source identification methods described above. The processing of cyclo-stationary signals has recently been boosted by the proposal of fast transforms (computation of the spectral correlation) and by the extension of the theory to time-angle descriptors ideally suited to machines operating under unsteady regimes.

In the frame of this work package, the partner will explore the advantage to use cyclo-stationarity approach for analysing typical Airbus acoustic signals. Then the partner will develop, assess and validate the cyclo-stationarity approach.

WP2.2: Validation of cyclo-stationarity on typical Airbus use cases.
In the frame of this work-package, Airbus will provide test data with an increasing level of complexity in term of signal to noise ratio. All these test data will be analysed (from simulation signals to real ones) and results will be discussed with Airbus. At the end, the applicant will provide a description of algorithms and dedicated toolbox with test cases

WP3: Aeroacoustic sources localization based on sparse approaches in order to improve the resolution and the quantification with a possible application to turbomachinery.

The experimental investigation of aeroacoustic sources is generally based on microphone array measurements. The acoustic pressure radiated by the source is synchronously acquired at microphone positions, and acoustic imaging technique is used to extrapolate the source distribution. In many situations, this problem is ill conditioned because of the acoustic radiation operator, and because the number of microphones is largely smaller than the unknowns source descriptors.

WP3.1: Assessment of Bayesian approach for acoustic localization.
The partner will explore recent developments which are based on a probabilistic formalism of the problem (known as Bayesian focusing), that offers a consistent framework for considering different kind of a priori information, for instance the sparsity of the source, or some information about its spatial correlation structure. This could improve the capabilities of acoustic imaging methods in terms of resolution and quantification. The partner will develop, assess and validate such approach.

<u>WP3.1: Validation test of Bayesian approach for acoustic localization</u>.
The partner will validate on realistic sources distribution thanks to a test the benefit of Bayesian approach for acoustic localization purpose. The partner will deliver at the end the methodology.

Tasks		
Ref. No.	***Title – Description***	***Due Date***
WP1	**<u>Aeroacoustic source separation: in particular the extraction of acoustic component from hydrodynamic component but also the different acoustic component.</u>**	T_0+36 months
WP1.1	Extraction of acoustic component from hydrodynamic by the use of stochastic modelling	T_0+30 months
WP1.2	Extraction of acoustic component from hydrodynamic by the use of structural vibration measurements	T_0+36 months
WP2	**<u>De-noising techniques based on cyclostationarity in order to improve data analysis.</u>**	T_0+25 months
WP2.1	Cyclo-stationarity proof of concept	T_0+18 months
WP2.2	Validation of cyclo-stationarity on typical Airbus use cases	T_0+25 months
WP3	**<u>Aeroacoustic sources localization based on sparse approaches in order to improve the resolution and the quantification with a possible application to turbomachinery.</u>**	T_0+36 months
WP3.1	Assessment of Bayesian approach for acoustic localization	T_0+24 months
WP3.2	Validation test of Bayesian approach for acoustic localization	T_0+36 months

3. <u>Major deliverables/ Milestones and schedule (estimate)</u>

Deliverables			
Ref. No.	***Title – Description***	***Type (*)***	***Due Date***
D1.1	Progress report on extraction of acoustic component from hydrodynamic by the use of stochastic modelling	R	T_0+18 months
D1.2	Delivery of algorithms (with a detailed report on methodologies including limits and gain) and tests cases.	R+D	T_0+29 months
D1.3	Progress report on extraction of acoustic component from hydrodynamic by the use of stochastic modelling structural vibration measurements	R	T_0+18 months
D1.4	Delivery of algorithms (with a detailed report on methodologies including limits and gain) and tests cases.	R+D	T_0+36 months
D1.5	Delivery of test data and test report with structural vibration measurements	R+D	T_0+36 months
D2.1	Report on cyclo-stationarity and presentation of the proof of concept	R+RM	T_0+16 months
D2.2	Delivery of algorithms (with a detailed report on methodologies including limits and gain) and tests cases.	R+D	T_0+25 months

Deliverables			
Ref. No.	***Title – Description***	***Type (*)***	***Due Date***
D3.1	Report on the assessment of Beyesian approach	D	T_0+25 months
D3.2	Delivery of test data on localization	D	T_0+32 months
D3.3	Delivery of algorithms (with a detailed report on methodologies including limits and gain) and tests cases.	R+D	T_0+36 months

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

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M1	Kick-off meeting	M	T_0
M2	Validation of criteria to assess the methodologies	RM	T_0+6 months
M3	Test readiness review for vibration test	M	T_0+24 months
M4	Test readiness review for acoustic sources	M	T_0+28 months
M6	Final meeting	RM	T_0+36 months

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

At least, every 6 months, a review meeting shall be organised.

Schedule for Topic Project:

Indicative start date is Q2 2017.

	2017		2018				2019				2020	
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
WP1.1						▲				▲		
WP1.2						▲						▲
WP2.1					▲							
WP2.2								▲				
WP3.1								▲				
WP3.2												▲

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

Special Skills:

The partners shall demonstrate high skills in signal processing and mathematics and shall master notions such as:

- Cyclostationarity
- Acoustic sources separation by the use of spatial filtering effect and source localization
- Stochastic modelling, Gaussian process, sparse approach, Bayesian approach

The supplier shall demonstrate that it masters these notions (by the means of publications….)

Capabilities:

The partner shall have an anechoic room to be able to make acoustic localization test and the associated microphones to conduct the test.

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

II. High fidelity Large Eddy Simulation using reduced model for engine broadband noise prediction

Type of action (RIA or IA)	RIA		
Programme Area	LPA, Platform 1, WP1.1.1		
Joint Technical Programme (JTP) Ref.	JTP_v5		
Indicative Funding Topic Value (in k€)	600 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	36 months	**Start Date**[2]	Q2/2017

Identification	Title
JTI-CS2-2016-CFP04-LPA-01-19	High fidelity Large Eddy Simulation using reduced model for engine broadband noise prediction
Short description (3 lines)	
Improvement of Open Rotor and UHBR Fan broadband noise prediction by using high fidelity reduced model Large Eddy Simulation methods with focus on turbulence in boundary layers and wakes, by direct noise computation or by providing enhanced inputs to broadband noise semi-empirical models	

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

1. Background

Over the last decade, major research efforts succeeded in drastically reducing the strong tonal noise of Contra-Rotating Open Rotor engines (CROR) thanks to extensive testing and development of advanced modelling methods. Now, the broadband (BB) noise becomes a significant part of the emitted noise, while limited research efforts have been put on its prediction.

The two main sources of broadband noise for the CROR (resp. for a Fan stage) are

- The trailing edge noise (“TE noise”) due to the deformation of the turbulent vortices contained in blade boundary layers when they pass the blade trailing edges.
- The wake interaction noise (“WI noise”) due to the interaction of the front blades wake turbulence with the rear blade (resp. stator vanes) leading edges.

CROR and Fan broadband noise prediction processes rely today on semi-analytical tools developed using simplified geometry assumptions and fed several turbulent quantities inputs based on empirical laws derived from simplified configurations (2D profiles and low pressure fans) and at lower Mach number (typically Mach number 0.1/0.2). Indeed, numerical simulations were not able up to now to handle such configurations, mainly due to unaffordable computational times at such high Mach & Reynolds numbers. Tonal noise can be tackled by using Unsteady Reynolds Averaged Navier-Stokes (URANS) computations (see the large number of publications that came out in the last few years), whereas broadband noise computations requires higher fidelity Computational Fluid Dynamics (CFD) methods, such as Large Eddy Simulation (LES) to provide detailed information on turbulence quantities.

The objectives of this work will be:

- To build improved turbulence statistics laws to feed the semi-analytical methods by the use of high fidelity CFD methods. This will allow to access realistic conditions and far more detailed flow features and parameters than flow quantities usually available from wind tunnel tests.
- To provide validated high fidelity (at higher cost) methods for direct broadband noise computation

The high fidelity prediction of trailing edge noise requires to accurately resolve the blade boundary layer in the numerical simulations, while simulating the wake interaction noise require an accurate representation of the turbulence generated in the blade wakes and its propagation donwstream to the rear blades (resp. stator vanes). The idea is thus to develop/adapt and apply highly efficient Large Eddy Simulation methods (LES) to handle such CROR & Fan-OGV[3] configurations, either by using an extremely highly scalable CFD code (on thousands of processor) or using a reduced order model (e.g. computing only one or a few 3D blades for each stage and taking into account effect of the other blades with an appropriate modelling techniques similarly to what is done for the phase-lagged approach of URANS simulations).

For the trailing edge noise, the approach will be to work first on a non-rotating static airfoil computations to reproduce existing WTT experiments, that will be provided by the Topic Manager. Finally 3D rotating blades simulations will be performed to understand both three dimensionnal and rotation effects.

Regarding the wake interaction noise, the work will focus on developing and validating an efficient method with a relatively moderate computational cost.

Finally a complete CROR & a complete Fan/OGV configuration will be computed using the previously developped tools.

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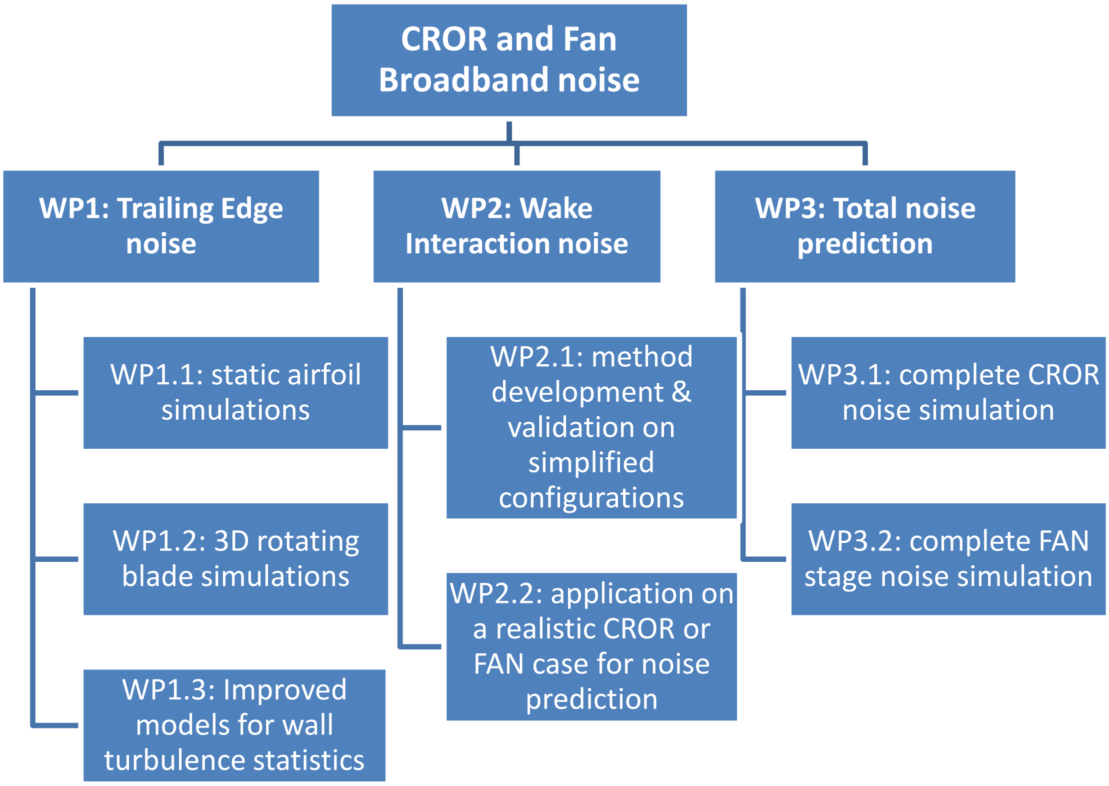
[3] Outlet Guide Vanes

Results, models & tool will be made available to the topic manager.

The proposed work structure breaks down as follows:



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

The objective of the work is to develop (if necessary), valid and perform high quality LES and associated noise prediction on CROR & Fan configurations in order to improve broadband noise prediction process. The applicant will use geometries and operating conditions prescribed by the topic manager.

<u>WP1 – Trailing Edge noise</u>

<u>WP1.1 – Static airfoil simulations</u> [M0- M0+18]
Wall resolved Large Eddy Simulations (LES) shall be performed by the applicant on non-rotatingNACA0012 and CROR profiles that will be provided by the topic manager at the beginning of the project. Several Mach numbers ranging from 0.2 to 0.8, together with several angles of attack shall be computed, meaning a high number of computations. A highly scalable LES solver is therefore required to allow the computation of the full matrix, with adapted mesh resolution to capture the detailed dynamic of the turbulent boundary layers. In addition wall model techniques should be tested and compared with reference wall resolved LES simulations and existing experimental data to understand their ability to reproduce wall turbulence statistics and pressure fluctuations at lower cost (helpful for WP1.2)

Based on these computations, the following activities shall be performed:

- Validation of the method by comparison with the experimental database from inputs delivered by the topic manager
- Enrich the experimental database with conditions that will not be tested (highest Mach numbers 0.7/0.8), with additional probes and with more comprehensive turbulence statistics.
- In-depth analysis of the turbulence of the boundary layer and extraction of the general trends in reponse to various parameter variations (profile shape, Mach number, chordwise pressure gradient)
- Derive improved inputs for TE noise models (wall pressure spectra, convection velocities, spanwise correlation lengths), in connection with WP1.3.

WP1.2 – 3D rotating blade simulations [M0- M0+18]

For this task, Large Eddy Simulation of a single propeller (provided by the topic manager) shall be performed for three different rotational speeds corresponding to the three acoustic certification point conditions (approach, cutback and sideline). Due to the computational domain size, the same mesh resolution as in WP1.1 may not be reachable, but a special care of mesh refinement in the boundary layer shall be taken. Mesh size reduction techniques such as wall modelling could be used, provided that the applicant demonstrates that the turbulence structures responsible for the trailing edge noise emission are properly represented by the technique.

The applicant shall perform direct noise computations from those simulations to be compared with experimental data provided by the topic manager, but also compute the same statistics as in WP1.1 to evaluate potential differences between rotating 3D blades and static 2.5D airfoils. This last activity shall feed WP1.3.

WP1.3 – Improved trailing edge noise model [M18 - M0+24]

In this task, the applicant shall use all data delivered by the topic manager and from WP1.1 and WP1.2, to build new empirical models for wall pressure turbulent spectra, convection velocities and spanwise correlation lengths in the objective to feed semi-analytical TE noise models. The objective is to build models that would be more universal and better applicable to high speed CROR or Turbofan blades than currently available models, for instance:

- Wall pressure turbulent spectra: Rozenberg, AIAA Journal, Vol. 50, No. 10 (2012), *Wall-pressure spectral model including the adverse gradient effects*
- Convection velocities: Gliebe, AIAA paper 2002-2490, *Fan broadband self noise prediction model*
- Spanwise correlation length: Efimtsov model, see Salze, AIAA paper 2014-2909, *An experimental characterisation of wall pressure wavevector-frequency spectra in the presence of pressure gradients*

The topic manager will provide feedback on the impact of those new models on CROR & FAN TE noise predictions.

WP2 – Wake Interaction noise

The objective of this work package is to develop and assess a computationally efficient LES method capable of computing rotor/rotor (resp. rotor/stator) wake interaction noise. The method shall be able to generate accurately the wake turbulence of the front rotor, propagate it downstream to the rear rotor (resp. stator vanes) and produce the appropriate interaction and noise generation on the rear stage. It shall in particular have rotating mesh and sliding planes capabilities.

Due the high Reynolds and high Mach numbers, the mesh requirements means a very high number of points. In order to minimize the computational cost and to provide a tool that can be used during a developemnt phase in a 3-5 years time-frame, a reduced order model that must not compute the full rotor but a single (or a few) blades/vanes of each stage while still accounting for the influence of the other blades/vanes is mandatory. Note that using classical periodic boundary condition will not work (will induce periodic forcing and lead to spurious turbulence coherence) whereas phase-lagged boundary conditions looks more adapted.

WP2.1: method development & validation on simplified configurations [M0 - M0+24]

In this task the chosen numerical approach must accurately reproduce the following physical aspects:

- The generation of the near wake turbulence just behind the front blade.
- The propagation of the wake turbulence on the rear stage. Experimental data (using Particle image velocimetry techniques) of the wake of the front rotor in single rotor configuration will be provided by the topic manager for validation.
- The interaction of the wake turbulence with the rear stage and the noise emission: as the interaction noise is (for a first order approximation) a non-viscous phenomenon (see for instance Amiet model), the accuracy of the simulation for the boundary layer of the rear blade may not be critical and options to improve the computational cost may be investigated there.

The validation of the method may be done on simplified configurations applicable for each of the three above aspects.

WP2.2: application on a realistic case for noise prediction[M0+24 - M0+30]

The methods will be applied one realistic CROR configuration or on one realistic Fan configuration (depending on CROR 2017 decision gate) provided by the topic manager.

In addition, the simulation shall be post-processed to provide improved inputs to the semi-analytical models (wake turbulence spectra, integral length scale, anisotropy just upstream of rear rotor).

WP3 – Total noise

WP3.1: complete CROR noise simulation [M0+30 - M0+33]

The method developed in WP1 & WP2 will be applied on a realistic CROR configuration provided by the topic manager. Far field noise shall be computed for three rotational speeds corresponding to the three certification conditions (approach, cutback and sideline).

A comparison with a wind tunnel experimental database and corresponding semi-analytical computations, all provided by the topic manager, shall be performed. The comparison will be performed for the total far field radiated acoustic power and the far field directivities.

WP3.2: complete Fan stage noise simulation [M0+30 - M0+36]

The developed method shall be applied on the NASA-SDT fan stage geometry. This task will be performed in the frame of the AIAA broadband noise prediction benchmark for which an experimental database has been disseminated (hotwire wake measurements and far field noise directivities).

3. Major deliverables/ Milestones and schedule (estimate)

		Year 1				Year 2				Year 3			
	Task	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**	**Q12**
WP1	**Trailing Edge noise**												
WP1.1	Static airfoil simulations	■	■	■	■	■	■						
WP1.2	3D rotating blade simulations	■	■	■	■	■	■						
WP1.3	Improved models for wall turbulence statistics							■	■				
WP2	**Wake Interaction noise**												
WP2.1	Method dev. & valid. on a simplified conf.	■	■	■	■	■	■	■	■				
WP2.2	Application on a realistic case for noise prediction									■	■		
WP3	**Total noise prediction**												
WP3.1	Complete CROR noise simulation											■	
WP3.2	Complete fan stage noise simulation											■	■

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D1.1	Static airfoil simulations – First year report	Report	M0+12
D1.2	Static airfoil simulations – Final report	Report	M0+18
D1.3	3D rotating blade simulations – First year report	Report	M0+12
D1.4	3D rotating blade simulations – Final report	Report	M0+18
D1.5	Trailing edge noise: improved models for wall turbulence statistics	Report + models	M0+24
D2.1	Validation of the method on simplified configurations - First year report	Report	M0+12
D2.2	Validation of the method on simplified configurations –second year report	Report	M0+24
D2.3	Complete CROR or FAN wake interaction noise prediction – Final report	Report & results	M0+30
D3.1	CROR total noise prediction	Data	M0+33
D3.2	Fan stage total noise prediction	Data	M0+36
D4.1	CFD tool able to compute complete CROR & Fan configuration delivery	Tool	M0+36
D4.2	Final Project Report	Report	M0+36

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Review of detailed work plan for all tasks & input delivery from Topic manager	Meeting	M0+3
M2	Project closure meeting	Meeting	M0+36

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

Demonstrated capabilities in:

- Advanced high fidelity computational unsteady aerodynamic modelling (Large Eddy Simulation, LES)
- Capability to produce 2.5D profile non-rotating LES computations with a reasonable turnaround time by using highly scalable code
- Capability to produce 3D rotating computations using reduced order model LES techniques (e.g. phase lagged approach), while not significantly compromising result accuracy
- Capability to compute far field noise from a LES computation of rotating bodies
- Flow turbulence and aeroacoustics physical analysis, a background on broadband noise analytical modelling is a plus.

The CFD code used for 3D rotating reduced model LES shall be made available to the topic manager during the whole duration of CS2 (LPA) project since it shall be used to predict broadband noise of CROR / UHBR demonstrators.

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

III. <u>Hybrid Machining for High Removal Rates and Surface Integrity Applicable for Safety Critical Super Alloy Parts</u>

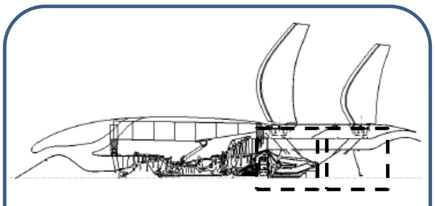
Type of action (RIA or IA)	IA		
Programme Area	LPA, Platform 1, WP 1.1.3		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	700 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	36 months	**Indicative Start Date**[4]	Q2 2017

Identification	Title
JTI-CS2-2016-CFP04-LPA-01-20	Hybrid machining for high removal rates and surface integrity applicable for safety critical super alloy parts
Short description (3 lines)	
Development of hybrid machining processes (machining combined with other processes such as laser and abrasive water jet) applicable to super alloys. The objective is increased removal rates compared to conventional machining with focus on surface integrity for safety critical parts.	

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

1. Background

The Clean Sky 2 programme aims at developing and demonstrating competitive and environmentally friendly technologies for commercial air transport. One technology strand consists of flight demonstration of the Open Rotor concept that is ground tested in Clean Sky 1. This CfP topic aims at supporting the continued development of rotating frames technologies, shown in the illustration to the right, while at the same time bring benefits for conventional engine architectures like hot section components in a geared ducted fan concept. In support of such dual use of the developed technologies, it is currently foreseen that rotating frames will be made from nickel based precipitation hardening super alloys. Structural integrity and safety of engine critical parts have to be considered with regard to design, manufacturing aspects, maintenance and overhaul. Rotating frames are considered as engine critical parts and are therefore subject to corresponding requirements and regulations. In manufacturing, material removal processes with guaranteed good surfaces will be required at the same time as the speed of material removal is critical to reach a cost of the engine that will be affordable and thereby enabling a competitive European aerospace industry.

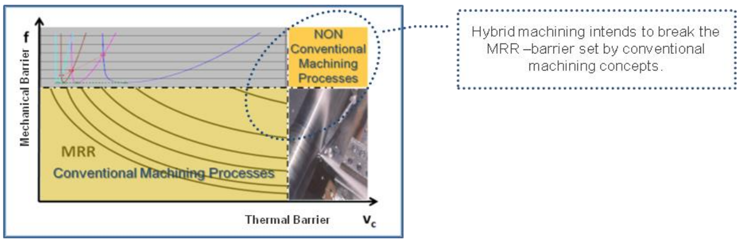


Rotating frames in an open rotor engine

Material Removal Rate – Hybrid Machining

Traditionally, machining effectiveness has been defined by the attainable Material Removal Rate; MRR. The MRR is usually expressed as the product of speed, feed and depth of cut. Thus, a high removal rate is in general synonymous with high cutting speed and feed while the cutting depth usually is as small as possible due to "near net shape" designs of the raw materials.

However, there are a lot of limiting factors to reach the theoretical maximum level of the material removal rate. The combination of work piece and machining method will set the boundaries for acceptable cutting forces and thereby define the set-up and clamping requirements. The combination of tool and work materials sets restrictions to productivity regardless of the concepts chosen for clamping through the wear rate and life of the tools. The wear in turn will define the efficiency of the operation through the number of non productive tool changes, following the wear rate that is primarily related to cutting speed, seen as the thermal barrier in the illustration. Therefore thermal control of the machining operation is imperative. In a similar notion, mechanical loads can be seen as a barrier to overcome, in order to maximize the tool engagement i.e. cutting feed.



An extended potential for improved productivity can be reached through application of Non-Conventional material removal concepts, that in combination with conventional methods will constitute the concept of Hybrid

Machining. While the Non-Conventional methods in general are methods of high energy density, like laser or abrasive water jet, slightly different strategies must be applied in this part of the MRR–space, due to material performance and part integrity.

The seemingly most interesting and viable application concept to reach this extended area of productivity is a machine tool where Conventional and Non-Conventional material removal concepts are integrated. Such concepts are available on the machine tool market, where additive manufacturing by means of "blown powder" is the most recent application. Thus, the added functionality of a high energy beam used for cutting cannot be expected to offer much difficulty for implementation in an existing machine tool and is basically already in place.

High Removal Rate Concepts – Feature Based Machining

The proposed concepts focus on super alloys and their ability to be machined by "high energy" methods. Therefore, analysis of the impact from the process on the material during and after processing is imperative and special attention must be set to post machining methods in order to safe-guard the finished surface from any process induced anomaly. To further focus on the application of the developed concepts, typical engine features like guide vanes, rings, flanges and items with large internal voids will be addressed. Such "feature based" strategies enables the definition of generic and efficient material removal concepts with focus on specific functionality requirements from a design perspective rather than from the generic capabilities of individual machining methods.

Hub:	External material removal; Internal or semi internal material removal in centre bore
Ring:	Mostly external material removal
Vane:	External and Internal material removal; Holes (shaped), High L/D –ratios
Flange:	Mostly external material removal; Holes and Scallops, Low L/D –ratios

Industrial Impact and Scientific Justification

The raw materials used for any high performance structural part – rotating or static – can be expected to be forged. Thus, it is likely to have material in excess to safeguard the material microstructure. Therefore a relatively large volume of raw material is usually left to be removed before further handling and finishing. Rough machining of such parts, like the hub sub assemblies from the shown listing, can be equivalent to 50% of the total machining time for the part. Similar numbers exist for the other parts and features presented.

The industrial incentives in the application of fast and low cost machining concepts are therefore apparent and at the same time exhibit relevant academic questions related to material properties and possible impact on part integrity, operator safety and environmental impact.

The reference machining concept for bulk removal of material (rough machining) is High Speed Milling with conventional tools, cemented carbide or ceramic. The reference alloy is Alloy 718 even if other super alloys like Waspaloy and Haynes 282 are included in the scope of the research. Thus, the hybrid concepts to be studied include combinations of Milling, Laser Beam Machining and Abrasive Water Jet Machining and can be applied to a vast number of components throughout, among others, the hot parts of the engine.

2. Scope of work

In the first parts of the project the specific components, like hubs, rings, vanes, etc. are to be analysed with respect to MRR from a "feature" perspective. Relevant specimens for various tests are to be manufactured and analysed with respect to surface integrity and the residual stress state as well as performance (fatigue tests) in the intermediary part of the project. In the latter part, final tests and analysis will be undertaken as well as the manufacturing of small concept prototypes (part of a flange, a milled surface or similar) to demonstrate the achievements from a product perspective.

The following tasks will be performed:

Tasks		
Ref. No.	**Title - Description**	**Due Date**
1	**Project Management** The partner shall nominate a team dedicated to the project and should inform CfP Topic manager about the name/names of this key staff. At minimum the responsibility of the following functions shall be clearly addressed: Programme (single point contact with Topic Manager), Engineering & Quality. **Progress Reporting & Reviews** Monthly one-pager and quarterly progress reports in writing shall be provided by the partner, referring to all agreed work packages, technical achievement, time schedule, potential risks and proposal for risk mitigation. Regular coordination meetings shall be installed (preferred as telecom). The partner shall support reporting and agreed review meetings with reasonable visibility on its activities and an adequate level of information. The review meetings shall be held quarterly by WEBEX, at Topic Manager's premises or at the partner's premises.	**M 36**

Tasks		
Ref. No.	**Title - Description**	**Due Date**
2	**High Speed Hybrid Machining** The primary aim of this work package is to establish a "safe" work allowance for final machining with respect to tool type (cemented carbide or "super abrasive") and machining parameters. The industrial need for such development relates to surface integrity requirements while machining at the lowest possible cost. The task will specifically address temperature control such that both added heat (lower cutting force) and reduced heat (prolonged tool life) can be studied. **Results and Deliverables** Added heat is expected to be arranged by means of laser or induction, directed to the work piece before or during machining. Simulation of the preheat impact on the work material is expected whereas controlled reduction of heat is expected to be arranged by means of application of temperature controlling media (presumably water based) under pressure on the rake as well as on the relief side of the inserts during machining. A fatigue test shall be included for verification of the final process parameters.	**M 33**
3	**Water Jet Hybrid Machining** This task will focus on applications where advanced use of abrasive water jet may play a new and significant role with respect to productivity. With a multi axis (5-axis) head further options for an extended range of applications seems reachable. The intention is to find the real potential for machining three dimensional surfaces in a milling like set-up. In addition, features like rounded corners, bevels and compensation for geometry imperfections will be addressed for conventional two-dimensional water-jet cutting. **Results and Deliverables** The control of the machine behaviour is essential. Therefore simulation of the process parameters with respect to the expected part geometry and movement of the abrasive jet is required. Software possible to integrate in a CAM environment is therefore one expected outcome of this work package. Further, an investigation of the machined surfaces with respect to contaminants must be undertaken. A fatigue test shall be included for verification of the final process parameters.	**M 33**

Tasks		
Ref. No.	**Title - Description**	**Due Date**
4	**Laser Beam Hybrid Machining** This task will include machining experiments with the primary intension to find the set of process parameters that leaves an acceptable integrity of the remaining surface. Since this concept can be expected to have limits in applicability with respect to material thickness the most important features to be investigated are flanges (holes, outer diameter and scallops) and thinner sections like most boundary surfaces of subparts, like preparation of weld joints for subsequent fabrication. **<u>Results and Deliverables</u>** In the evaluation of this hybrid concept, supporting processes for removing recast layers and other defects generated in the machining process must be included. A fatigue test shall be included for the final process parameters.	**M 33**

3. Major deliverables/ Milestones and schedule (estimate)

During the course of the project advancements of generic nature are expected to be reported and demonstrated in a form acceptable for publication in academic journals and other papers. Advancements of product specific nature are to be presented in technical reports and seminars for use or attendance by the members of the project consortium only.

The work will follow the time schedule below:

Month	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
1 Mgmt			D1									M TR						M TR												M TR						D5
2 Milling			M 1						M 2						M 3									M 4									D2			
3 AWJ			M 1						M 2						M 3									M 4									D3			
4 Laser			M 1						M 2						M 3									M 4									D4			
																																	D 2-5: Reports			
																														MTR 3: Wrap-Up in Focus						
																								M 4: Progress and Result Review												
																		MTR 2: Fatigue in focus																		
															M 3: Work procedure proven successful																					
												MTR 1: Work Flow in focus																								
									M 2: Test set-up defined and approved																											
			D 1: Work plan including concept selection and coordination of feature requirements to process capability																																	
			M 1: Material procurement – Material sourcing established and approved																																	

Mid-term reviews (MTR) will be arranged in month 12, 18 and 30.

List of deliverables

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	Plan including concept selection and coordination of feature requirements to process capability.	**R**	**M03**
D2	High Speed Machining: Final report and paper ready for publishing - Feature Based Machining and Hybrid Machine Tools in Aerospace Applications Based on Advanced Milling Concepts.	**R, D**	**M33**
D3	Abrasive Water Jet: Final report and paper ready for publishing - Feature Based Machining and Hybrid Machine Tools in Aerospace Applications Based on Abrasive Water Jet.	**R, D**	**M33**
D4	Laser: Final report and paper ready for publishing - Feature Based Machining and Hybrid Machine Tools in Aerospace Applications Based on Laser Cutting.	**R, D**	**M33**
D5	Final report.	**R**	**M36**

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

List of milestones

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	Material procurement - Material sourcing established and approved.	**R**	**M03**
M2	Test set-up defined and approved.	**R, HW**	**M09**
M3	Work procedure (including all steps) is fully functional and able to deliver expected results.	**R, D**	**M15**
M4	Progress and Result Review.	**R, D**	**M24**

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

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

- **Machine Equipment**
  The consortium should have work-shop facilities in line with the proposed deliverables (preferably) or, if such equipment is not available, existing relations with institutions or companies that accommodate such equipment and the possible need for equipment intended for advanced coolant applications.
    - Ultra-Sonic (milling capability for ceramic milling)
    - Laser (fiber laser capability and controllable for parameter optimization)
    - Abrasive Water Jet (multi axis tilt head)
    - Heat treatment (including induction heating for milling experiments)
    - Process monitoring equipment will be considered advantageous.

- **Research Tools**
  Sensor and data acquisition equipment must be available in line with the proposed deliverables and in particular for the physical units “Force [N]”, “Power [W]” and “Temperature [°C]”.
  Software for DoE (Design of Experiments) and MVA (Multi Variant Analysis).
  Experience from relevant metallurgical simulation and manufacturing process simulation is required.

- **Materials Laboratory**

  Facilities to perform material analysis and be able to prepare and mount metallographic samples in order to perform investigations of machined surfaces (cross section and top surface).

  Such investigations are expected to comprise,
  - Optical microscopy & scanning electron microscopy: FE-SEM; EBSD; EDS
  - Surface analysis capability: Hardness; Surface roughness.
  - Residual stress measurements: XRD; Drilling.
  - Fatigue test capability
  - Chemical analysis tools: GD-OES; EDS; XRF; Microsond

  The partner/consortium should preferably hold an "ISO/IEC 17025" certificate.

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

5. Abbreviations

MRR	Material Removal Rate
EDS	Energy Dispersive X-Ray Spectroscopy
EBSD	Electron Backscatter Diffraction
XRF	X-ray Fluorescence
GD-OES	Glow-Discharge Optical Emission Spectroscopy
FE-SEM	Field Emission Scanning Electron Microscopy
XRD	X-Ray Diffraction

IV. Design for High AN^2 (Disk and Blade attached)

Type of action (RIA or IA)	IA		
Programme Area	LPA, Platform 1, WP1.1.3.4.1		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	500 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	30 months	**Indicative Start Date**[5]	Q2 2017

Identification	Title
JTI-CS2-2016-CFP04-LPA-01-21	**Design for High AN^2 (Disk and Blade attached)**
Short description (3 lines)	
The objective of this topic is to develop ad-hoc and innovative methods and criteria in order to face the challenge to correctly design and predict stress level in innovative High Speed Power Turbine for next generation geared engine application. Those methods will be then validated through an extensive test campaign (both component test & spin rig test). *AN^2: turbine blade stress is proportional to AN^2. AN^2 is the product of the annulus mid-area along the rotor blade A and the blade rotational speed squared N^2*	

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

1. Background

Large High speed turbine usually works in really extreme condition for what regards Rotation Per Minute [RPM] and pull-load acting on the blade and on the disk attachment. The most noticeable aspect of the proposed high speed turbine will be that the working condition will move from state of art AN^2 to higher values (20 – 25% higher).

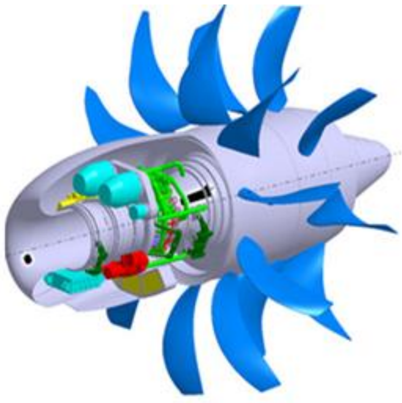


Figura 1: Counter Rotating Open Rotor Engine Configuration.

Due to the rotational speed, the pull-load on the blades results in a static stress and deflection (LFC) affecting the disk and blade stresses. Hence, this kind of turbine configurations will work under very specific conditions that could have a major impact on design, with different requirements compared to conventional Low Pressure Turbines.

Within this scenario it is crucial to avoid an excessive blade static stress and critical resonance in the operative range to enhance further the AN^2 on new standards.

Target of WP1.1.3 in LPA – Platform1 demonstrator is to validate at Flight a Counter Rotating Open Rotor, in which the Topic Manager has the responsibility of the High Speed Power Turbine.

To guarantee the achievement of the expected CTQs improvement (efficiency, weight, noise,…) with respect of schedule and specification, the successful execution of the topic content is required.

2. Scope of work

This proposal aims in advancing the current State of the Art for HS LPT. The key parameter that describes the technological level of high speed turbine is AN^2. As mentioned in the previous chapter it is foreseen within this proposal to improve the AN^2 20–25% higher. By increasing this parameter will be possible to design more compact and efficient High Speed Turbines extending the design space opportunities and performance at engine level. On the other hand by increasing the turbine shaft speed (N) and/or the turbine mass flow area (A) the pull-load becomes more challenging and hence there are several mechanical limitations in doing that. One of the most critical aspects is related to blade-disk attachment. Hence to go beyond the current legacy it is requested to develop and validate more innovative, accurate and robust design methodology for this area to be applied for future high speed demonstrators.

The proposed activity is planned through the following steps:

WP1 – Method Development (optimization) [M1 – M5]

High speed turbines have several point of attention for what regards structural integrity, as stated in the general scope of work, and current design solutions do not meet the goal to achieve 20-25% higher AN2. Overcoming this limitation will require from numerical point of view a more accurate design method which will allow reducing conservatism in current reserve factor through optimized shape, thus increasing the design space.

This numerical method will be developed in WP1 and applied to high speed LPT (Low Power Turbine) blade & disk in order to design an innovative layout for the Blade root attachment and prevent any Low Cycle Fatigue (LCF) phenomena to occur. The innovative and optimized blade and disk attachment designed through this method will be used as baseline to design the TA in the following WP. The method development will be under the applicant responsibility.

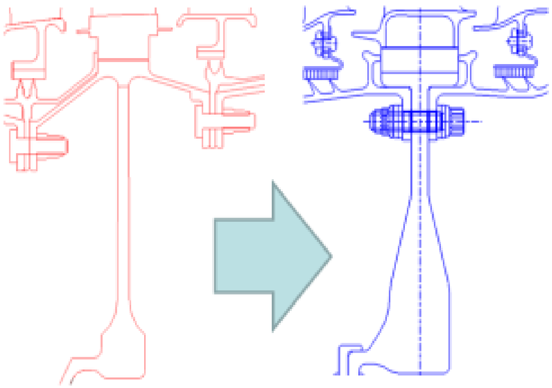


Figura 2 – Comparison between conventional (left) and High Speed (right) disks

WP2 – TA design (firtree and disks) [M5 – M21]

To prove and validate the numerical method developed in WP1 there will be the need to perform two dedicated test (with increasing representativeness) on TA with the optimized Blade & disk attachment:

1. Simplified component Test Article (TA) (dummy blade with real dovetail): TA is needed to perform preliminary component test. TA should be representative of the selected blade & disk attachment, while the blade geometry itself can be a dummy one. TA quantity should represent a statistically significant data set.
2. Detailed TA (Real blade and real disk): TA needed to perform spinning test. TA should be representative of the selected blade & disk attachment, also blade geometry needs to be representative. Special features needs also to be included in the TA in order to represent gas-loading deflection in different operating conditions.

The applicant will provide all the necessary detailed drawings for the TA and for the relative instrumentation (Detailed Drawings will be shared with the Topic Manager for approval)

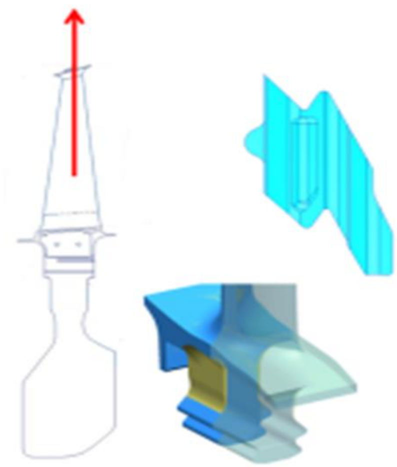


Figura 3 – Peculiar High Speed Blade features

The procurement of the P/Ns and the Test Articles (dummy blade with real dovetail and Real Blade/Real Disk) assembly is under the Topic Manager responsibility.

<u>WP3 – Rig design / Adaptation [M5 – M15]</u>

WP3 will be based on output coming from WP1 & WP2, defining how the test rig (both for component test and spin rig test) will be redesign in order to be adapted to the new TA to be tested. The tests, in order to meet time and schedule of the Topic, need to be performed in two existing test facilities:

1. Component test facility: Needed to test the simplified TA designed in WP2. The applicant needs to demonstrate to have access to an existing component test facility with capabilities representative of LPA 1.1.3 CROR engine operating conditions in terms of pull load; such conditions will be disclosed during the negotiation. The test facility needs to be adapted for TA optimized blade & disk attachment, as designed in WP2. The redesign and adaptation of the component rig will be completely under the applicant responsibility.
2. Spin rig test facility: Needed to test detailed TA. Spin rig is currently owned by Topic Manager. The applicant will provide detailed design for spin rig adaptation (Spin rig detailed design will be under Topic Manager responsibility) and TA assembly/disassembly procedure. The Topic Manager will be responsible of the spin rig adaptation.

<u>WP4 – Test & Data Appraisal & Method validation [M21 – M27]</u>

WP4 will be based on output coming from WP2 and WP3. The test campaign will be divided in two subsequent phases.

1. Component test: During the first phase the dummy TA (dummy blade and real dovetail) will be tested in the applicant component rig (readapted in WP3) capable of simulating the pull load acting on the real blade in engine condition. This test will be under the applicant responsibility and will be

supervised by the Topic manager.

2. Spin rig test: the second phase of the test will be carried on with the real TA (Representative Blade & Disk) in a spin rig which is capable of simulating both the RPM of the real LPT and also a representative temperature condition of the flow path. The spin rig chosen to perform this test is currently owned by the Topic Manager and thus the test will be entirely under the Topic Manager responsibility and supervision. The applicant will support the installation of the TA and will support the test also. After the test campaign the applicant will validate the method through a benchmark with the experimental results and report to the Topic Manager.

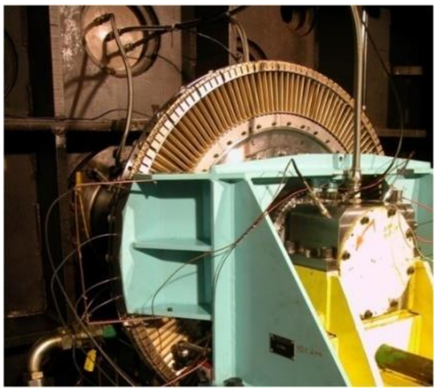


Figura 4: Spinrig

WP5 – CFP management [M1 – M30]

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

Work Package		
Ref. No.	***Title – Description***	***Duration***
WP1	Method Development Optimization	[M1 – M5]
WP2	TA design	[M5 – M21]
WP3	Rig design / Adaptation	[M5 – M15]
WP4	Test & Data Appraisal & Method validation	[M21 – M27]
WP5	CFP management	[M1 – M27]

3. Major deliverables/ Milestones and schedule (estimate)

Deliverable	Title	Type (*)	Description (if applicable)	Due date
D1.1	Method for design high AN2 developed	R	Method and tool available. Report and user guide	T_0 +5 months
D1.2	TA preliminary design report	R	Preliminary design of dummy & real TA defined	T_0+10 months
D1.3	Rig preliminary design report	R	Preliminary design of component test rig and spin rig defined	T_0+15 months
D1.4	TA detailed design report	R	Detailed design of dummy & real TA defined	T_0+15 months
D1.5	Rig detailed design report	R	Detailed design of component test rig and spin rig defined	T_0+15 months
D1.6	Component test report	R	Component test performed and report available	T_0+27 months
D1.7	Spin rig test report	R	Spin rig teste performed and report available	T_0+27 months
D1.8	Final project report	R	Method validated with experimental test benchmark. report	T_0+27 months

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

Milestones	Title	Type (*)	Description (if applicable)	Due date
M1.1	Tool & Method availability	R	Tool & Method available	T_0+5 months
M1.2	Ta design phase over	RM	Ta PDR/DDR performed	T_0+14 months
M1.3	Rig design phase over	RM	Rig PDR/DDR performed	T_0+14 months
M1.4	*Hardware availability (**)*	*D*	*Hardware available to test*	*T_0+21 months*
M1.5	Component test performed	RM	Component test done	T_0+14 months
M1.6	Spin rig test performed	RM	Spin rig test done	T_0+27 months
M1.7	Method validated	R	Method validated	T_0+27 months

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

*** Milestone under Topic Manager responsibility*

	T0+1	T0+2	T0+3	T0+4	T0+5	T0+6	T0+7	T0+8	T0+9	T0+10	T0+11	T0+12	T0+13	T0+14	T0+15	T0+16	T0+17	T0+18	T0+19	T0+20	T0+21	T0+22	T0+23	T0+24	T0+25	T0+26	T0+27
WP1: Method Development Optimization					D1.1 M1.1																						
WP2: TA design & Delivery										D1.2				M1.2	D1.4												
WP3: Rig design / Adaptation														M1.3	D1.3 D1.5												
WP4: Test & Data Appraisal & Method validation														M1.5							M1.4						M1.6 M1.7 D1.6 D1.7
WP5: CFP management																											D1.8

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

- Extensive and proven experience in design and validation of aerospace products (in particular Pressure Turbine sub-modules) is mandatory.
- 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 is a required.
- 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, design reports, risk analysis, FMEA, test plan and test requirements, test results, test analysis reports must be made available to the Topic Manager.
- An Implementation agreement will be proposed to manage the IPR and the relation between the Topic manager and the Applicant(s).

V. RIGHT (Rig instrumentation, test support & data analysis of High Speed Power Turbine)

Type of action (RIA or IA)	IA		
Programme Area	LPA, Platform 1, WP1.1.3.4.1		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	350 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	24 months	**Indicative Start Date**[6]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-LPA-01-22	**RIGHT (Rig instrumentation, test support & data analysis of High Speed Power Turbine)**
Short description (3 lines)	
The present work is mainly aimed at developing experimental features able to properly characterize the flow field and the aerodynamic efficiency of a turbine module to validate the specific technologies and solutions adopted for a high speed turbine. In particular, the acquired data should be able to characterize the unsteady 3-dimensional flow field developing inside the different blade rows of the rig, in order to further explain the loss production mechanisms, responsible for the efficiency of the module (measured by means of standard measurements at the shaft of the turbine) and to achieve more understanding of the effects of adopted specific design features. Furthermore, since the unsteady data acquired in the high speed test rig will include complex flow features, due to the unsteady interaction of a multi stage turbine, innovative (ad hoc developed) post-processing routines are requested in order to simplify and understand the problem. For example, proper orthogonal decomposition or time-space Fourier transform or ad-hoc modal reduction techniques should be applied to the unsteady results in order to reduce the order of the problem. The results will be adopted in order to establish design criteria for the optimization of high efficiency turbine blades for new concept aeroengines, as well as to verify different technology solutions tested in more simplified facilities.	

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

1. Background

The real flow field inside aero-engines is inherently strongly 3-dimensional and unsteady due to blade and vane 3-dimensional design as well as to the unsteady interaction between the different rows. The dimensionless flow parameters (i.e. Reynolds number, Mach number, passing wake reduced frequency etc.), which characterize the nominal operation of the aero-engine drive the viscous and compressibility effects, as well as the unsteady phenomena.

The low Reynolds number conditions typical of the cruise phase promote the possibility of separation prior to transition of the suction side boundary layer, with a dramatic penalty in terms of whole engine efficiency. The development of boundary layer transition and/or separation is sensibly affected by the upstream flow conditions in terms of homogeneous free-stream turbulence intensity as well as unsteady effects coming from upstream blade rows.

The high Mach number conditions are instead responsible for strong compressibility effects, that may eventually induce the formation of shock waves at the exit of both stator and rotor rows (or for some sections of the rotor blade also at the entrance). Shock waves are inherently dissipative, and also further contribute to the loss generation due to their interaction with the blade (or vane) boundary layers. Potential and viscous effects associated with the rotor/stator aerodynamic interaction sensibly contribute to the unsteadiness inside the real engine, thus to a time-frequency modulation of the aerodynamic flow field developing on the different blade rows, and consequently of both the aforementioned viscous and compressibility effects. In multistage machines the sequence of stages further increases unsteadiness and blade rows interaction phenomena. To this hand clocking (circumferential indexing of homologous blades) and gaping (axial spacing between different kind of rows) are geometrical parameters sensibly influencing the aerodynamics of the stages, since they affect the migration, bowing, stretching and definitively the mixing of wakes shed by upstream rows. These effects have a strong influence on the loss generation mechanisms as well.

With respect to simplified geometries and research facilities (such as cascade tests for example), cold flow rotating rigs are also able to correctly reproduce the 3-dimensional effects associated with the radial equilibrium and the 3-dimensional blade geometry that induce strong cross-flow pressure gradients. They act pushing the low momentum fluid regions coming from upstream toward the direction identified by the pressure gradient. Secondary flows developing at the hub and the tip vortex of unshrouded rotor blades are a typical example of low momentum fluid regions whose migration is strongly influenced by the aforementioned pressure gradients, as well as by the unsteady interaction with structures coming from previous rows (the effects known in literature as vortex-vortex interaction).

All these considerations make tests on a high speed cold flow rotating facility able to reproduce both the Mach and the Reynolds number similarities mandatory for a proper estimation of a whole stage efficiency operating under realistic flow conditions (thus providing high TLR and high fidelity results for design criteria validation). Indeed, the possibility of extracting experimental results in high speed rotating rigs reproducing the geometrical and the flow conditions is a challenge that may sensibly contribute to optimize new generation turbine modules as well as to improve the capability of CFD codes to predict the real flow field, and thus efficiency. In fact, there are intrinsic problems associated with the instrumentation for flow analysis in unsteady 3-D flow field of multi-stage high-speed machines. For example, the small dimensions require the realization of miniaturized instrumentation; the high frequencies of the unsteady flow phenomena require instrumentation with very high frequency resolution able to resolve flow angles, velocity, pressure and temperature fluctuations; the interactions between absolute and rotating frame of reference can be correctly resolved with measurements in the absolute frame of reference supported by measurements in the rotating frame of reference by means of a telemetry system with a proper frequency resolution. This kind of instrumentation in the recent past has been adopted in low speed facilities, but never adopted in high speed rotating machines of this complexity where only time-averaged data are measured achieving only an overview of overall performance. Hence, it is necessary to study and develop suitable non-intrusive measuring techniques and data reduction tools for the High Speed Rotating Rig in order to obtain relevant unsteady data analysis to support the design and validation of innovative configurations.

2. Scope of work

The present work is mainly aimed at developing experimental features able to characterize the flow field and the aerodynamic efficiency of different turbine modules. The relevant instrumentation equipment will be installed within the high speed research turbine of the Topic Manager company. In particular, the acquired data should be able to characterize the unsteady 3-dimensional flow field developing inside the different blade rows of the rig, in order to further explain the loss production mechanisms, responsible for the efficiency of the module (measured by means of standard measurements at the shaft of the turbine). Particularly, innovative (ad hoc developed) measurement chains and corresponding post-processing tools should be developed by the applicant in order to clearly identify the source generating unsteadiness, thus provoking flow distortion and detrimental effects for losses, also in high speed rotating rig (not frequently done at the moment). The results of the unsteady investigation will enable the establishment of design criteria for the optimization of high efficiency turbine blades for new concept aero-engines, as well as to verify different technology solutions tested in more simplified facilities. The work will be split in X different tasks:

- Task 1: Identification of the instrumentation, position and dynamic properties of complementary measurements techniques for the identification of the main unsteadiness sources characterizing the different design choices;
- Task 2: Installation and commissioning of the instrumentation;
- Task 3: Development and calibration of in house post-processing tool for the clear identification of unsteadiness from previous established high frequency response sensor (both the static and the rotating frame should be resolved);
- Task 4: Testing, data post-processing and analysis of the data

Task 1: Within the present Task an appropriately designed measurement procedure, constituted of innovative measuring techniques, whose acquired data should be reduced with advanced post-processing tools, should be designed and developed. The Applicant(s) should identify, jointly with the Topic Manager, the experimental needs to validate implemented technologies, the main characteristics of the rig, and then the most suitable measuring techniques to extract unsteady results describing the time-varying flow field (and/or the pressure field or other objective functions to be defined with the Topic Manager). The measurement techniques should provide a proper interpretation of the unsteady phenomena providing a clear link between these phenomenon and the related loss production mechanisms, thus providing information on the overall aerodynamic efficiency data, as well as the detailed unsteady evolution of the flow inside the rig. To this end, the measurements should be carried out in the absolute and/or possibly in the relative frame of reference by means of a telemetry system. Due to the constraints imposed by the high speed condition (high aerodynamic head), small geometrical dimensions and gaps for the probe insertion and/or optical access, the Applicant(s) should provide a detailed CFD analysis in order to identify the best strategy for instrumentation and sensitivity to expected results. In fact, the measurements in a High-speed test rig with realistic condition has strict constraints that may limit the use of conventional instrumentations. For example, blockage effects of different kind of probes (if any) should be also considered in order to optimize the disposition of the instrumentation, thus improving the accuracy of the results.

The quantities to be measured (i.e. velocity, pressure, temperature etc.) as well as the main characteristics of the measurement chain (particularly its accuracy and frequency response) will be defined and established jointly with designers to add to the standard (actually state of the art) instrumentation the proposed innovative one in order to be suitable for the identification of the unsteady phenomena expected to directly influences the rig efficiency.

Task 2: In this phase of the project the test article and the other instrumentations will be installed in the research turbine in order to collect the requested data during the operation of the rig. To this end, the Applicant(s) should guarantee an in loco presence of experts during the preparation and tests phases.The Applicant(s) should directly interact with the topic manager and his team to verify that the proposed innovative measurements chain is installed in order to be able to identify the unsteady phenomena expected to directly influences the rig efficiency. during the instrumentation of the test article, as well as for the identification of the modifications to be applied on the casing (or other parts of the testing hardware) to allow probe insertion and/or optical access.

Task 3: The measurements should be characterized by sufficiently high frequency response in order to apply time-frequency analysis of the acquired data (i.e. temporal and spatial Fourier analysis to identify and split periodic from not periodic events as well as to recognize dominant energy peaks in the Fourier domain). This will allow a deep inspection of the rotor-stator aerodynamic interaction as well as common turbulence quantities. Particularly, the acquisition and the post-processing techniques should be able to decompose high and low frequency fluctuations rising into the flow due to the aerodynamic interaction between the different blade rows, due to the vortex-vortex interaction process as well as to other unsteady phenomena developing in the real stage. The Applicant(s) should develop and design a phase-locked ensemble-averaged acquisition procedure and further post-processing techniques that provide a reduction of the data-set to a limited number of information suitable to identify the most predominant phenomena involved in the generation of losses (i.e. Proper Orthogonal Decomposition POD or similar tools).

Task 4: After installation, commissioning and tests, data collected will be post-processed with the tools ad hoc defined and developed by the Applicant within the project with the aim of further assisting designers in the identification of unsteady phenomena sensibly influencing the time-varying flow field developing within the turbine. In this phase of the project, the Applicant(s) should analyze the data in order to identify the main causes of loss generation identifying the contribution of profile and secondary losses and evaluating the contribution due to the unsteady interactions of the blade rows. To this end, the post-processing procedure should be able to simply represent the problem using a modal reduction of the results (e.g, by means of POD or time-space Fourier analysis or ad-hoc reduction procedure).
A detailed comparison between experimental and CFD data is also requested in order to identify and develop high-fidelity CFD tools for the analysis of unsteady flows, thus an accurate efficiency evaluation.

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T1	Define innovative instrumentation list to be coupled with traditional rig instrumentation (preliminary rig implementation, expected costs and results).	T_0+5 months
T2	Detailed design of chosen instrumentation for test article. Instrumentation Drawings (with designers)	T_0+10 months

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T3	Instrumentation build/procurement, reduction data routines development, instrumentation and probes calibration.	T_0+15 months
T4	Installation of the instrumentation on test rig and test support. Experimental data reduction, numerical vs experimental comparisons.	T_0+24 months

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type (*)***	***Due Date***
D1	Instrumentation report	R	T_0+5 months
D2	Instrumentation drawings	R	T_0+10 months
D3	Instrumentation and probes calibration report	R	T_0+15 months
D4	Numerical vs Experiments comparison report	R	T_0+23 months

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

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M1	Instrumentation CDR	RM	T_0+4 months
M2	Instrumentation PDR	RM	T_0+9 months
M3	Instrumentation DDR	RM	T_0+14 months
M4	Installation of the instrumentation on test rig	D	T_0+19 months
M5	Experimental data reduction	RM	T_0+22 months

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

Schedule for Topic Project:

	T0 +1	T0 +2	T0 +3	T0 +4	T0 +5	T0 +6	T0 +7	T0 +8	T0 +9	T0 +10	T0 +11	T0 +12	T0 +13	T0 +14	T0 +15	T0 +16	T0 +17	T0 +18	T0 +19	T0 +20	T0 +21	T0 +22	T0 +23	T0 +24
Start of the project - KOM																								
Instrumentation definition				M1	D1																			
Instrumentation design									M2	D2														
Instrumentation readyness														M3	D3									
Test support																			M4					
Data reduction																						M5	D4	

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

Special Skills

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

- Expertize in the installation and employment of not-intrusive measuring techniques for detailed analysis of the three-dimensional time-varying flow field of multi stage machines (i.e. rotor stator aerodynamic interaction, clocking effects, turbulence measurements etc.);
- Expertize in acquisition, post-processing and data analysis in rotating machinery;
- Expertize in CFD calculations on rotating rig and CFD support to experimental testing, experience in unsteady analysis of stator-rotor interactions, turbulence and transition modeling in steady and unsteady turbomachinery flows with focus on low Reynolds and high Mach number flows (shock wave – boundary layer interaction);

It is also requested that Applicant(s) gives a continuous on-site support to test rig activities as well as the concurrence with topic manager for rig instrumentations.

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

VI. Low Cost, Smart Tooling for Composites

Type of action (RIA or IA)	IA		
Programme Area	LPA, Platform 1, WP1.2		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	500 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	18 months	**Indicative Start Date**[7]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-LPA-01-23	**Low Cost, Smart Tooling for Composites**
Short description (3 lines)	
The objective of this topic is the design and manufacturing a smart tooling for an advanced automatic composites manufacturing process for the engine integration on fuselage structure of Large Passenger Aircraft. The aim of this innovative automatic composites process is to achieve improvements 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.	

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

1. Background

This topic is allocated into the Clean Sky 2 where several demonstrators will be developed by the industry. The tasks within this project involve components from the Large Passenger Aircraft, these activities are part of WP1.2: Advanced engine integration driven fuselage.

Figure 3: Rear End

The final and main objective of WP1.2 is to reach fully maturation (TRL6) in design and manufacturing of a CFRP ground demonstrator of the Rear Fuselage that includes the VTP attachment zone with frames, skins and fittings that could be metallic. These components will be manufactured with maximum level of integration and reducing assembling work.

In order to achieve the appropriate TRL for some of the required components and envisioned processes some important developments have to be undertaken. The focus of this topic is the design and manufacture of an innovative system for the high rate production of high loaded frames in CFRP (VTP attachment area) and, eventually, other structural parts.

These frames will be designed with a CFRP system based in Out of Autoclave (OOA) technologies and the equipment object of this topic is intended to achieve an automated and flexible preforming process since this is the part of the process where automation is more needed and more challenging in the state of the art OOA processes. The innovative character of the process will be reflected in obtaining final part faster and in one shot, simplifying the process, saving energy and costs.

These activities can be implemented in a Rear Fuselage cone regardless of the engine configuration (CROR or UHBR) since the objective is to develop a flexible system capable of manufacturing frames located at different fuselage sections and submitted to different levels of loads.

Example of section dimensions: 3,5-4 m diameter and 3,5 m length

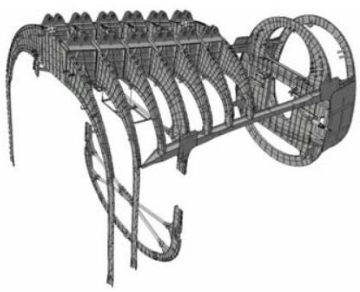


Figure 4: Shape of frames

The Partner selected will be responsible to develop, design, improve and modify the tooling to perform the parts. The topic Manager will be the responsible to manufacture the parts.

2. Scope of Work

The objective of most of the technologies involved in the LPA 1 IADP is to reach a maturity level necessary to allow flight testing of the Large Passenger Aircraft demonstrator. One of the main objectives is to develop a full CFRP whole structure and simplify the architecture for the future airplanes in terms of assembly and integration to enable weight and recurring costs reductions.

The general key challenges:

- To get automatic process to make these pieces
- Quality improvement (eliminating wrinkles…)
- Robust process (increase repetitiveness)

Press-forming tooling

Currently, the manufacturing process is to manually deposit the dry fiber layers, precut in a previous process, in the mould, placing parts layer by layer according to the required orientations and compacting every two or three layers. More automated process, like hot drape, are only suitable to some constrained geometries.
The limitations of manual and hot drape forming processes are in the amount of time used in the pre compaction of the preform, which produce many timeouts in the laminate, and the adaptation of the caul plates to the geometry of the part, which depends heavily on the skill of the operator, being a process almost handmade.
Also, there is a very high energy cost involved for generating the compaction vacuum every two or three layers, and make two hot forming at least for each piece, where the membrane must heat up the moulding tool and the fiber. Besides, the process is very time consuming and the hot drape machine utilization is very low due to long heating and cooling times. The key challenges related to press-forming are the following:

- To achieve a fully automated performing process able to manufacture different frames geometries.
- The system will be capable of manufacturing other structural parts modifying the tooling system attached (parts like, ribs, spars, stringers, etc)
- The system will be able to accommodate different geometries and thickness changes with parts that can be quickly replaced
- The system will increase the frontier of possible parts that admit automated performing processes in opposition to non reliable manual processes
- One shoot forming process
- The system will be able to manufacture components at rates of 60 a/c at least
- Temperature homogeneity in the forming area will be ±5º. Appropiate control system must be included.

In the frame of this topic, the partner must provide at least 2 solutions for High temperature (180º) forming device.
The device must be able to perform different sections of structures, “C” and “Z” shapes, ensuring compaction

and tolerances required by the materials and manufacturing process.
Different manufacturing trials must be performed in order to accept the press-forming device and auto-heating tooling. The main objective of the tests will be to reach geometry and thickness requirements and no wrinkles apparitions.
Other important parameter, for the correct automation of the process, is the auxiliary materials positioning. Additive 3D printing templates will be required for this task.

Curing tooling for new configurations and materials

The composite parts to be cured will have a high level of integration of different elements, resin channels and temperature homogeneity must be ensuring in the design phase.
For curing process, a high efficient tooling is needed in order to reach high quality in different manufacturing process. The tooling must be enough flexible to be adapted for Out of autoclave composites curing process and also for autoclave curing process.
The device must be flexible too. It will have a fixed part in which are placed the pressure and temperature systems necessary to set the plies to the required shape, synchronized with a mechanical part which is used to adjust the gap to the required thickness. The tooling will have another mobile and interchangeable part, that allow performing different parts, or in one piece to make small changes in size or shape, making small adjustments to the tool.
In this way we can make modifications to the frame, to fit the engine position without modify the tool, simply adjusting the tool to the new thickness or new shape of the forms.

The Partner shall:

- Propose the most suitable and innovative tooling design for the chosen technology to be applied for each Single Part, including mould, drill, trim, etc. to produce a part according to the drawing set.
- Define and Manufacturing Prototype Tooling that will assure the full functionality of each Single Part and, if needed, modify their designs in order to improve Single Part functionality.
- Define and Manufacturing Prototype Tooling that will assure the demanded quality of each part 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.
- 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.
- It will be appreciated and desirable if 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 be appreciated.
- Identify and report at least the following information: RC, weight (if applicable), materials, manufacturing procedures, LCA data, etc. always establishing the study versus the current solutions applied in industry.

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T0	Concurrence engineering and design composites development for tooling definition	*T0+6*
T1	Manufacture the Press-forming tooling.	*T0+10*
T2	Manufacture the Curing tooling for new configurations and composite materials.	*T0+16*
T3	Validation of the tooling as agreed with the TM (dimensional, air tightness…)	*T0+18*
T4	Delivery of the manufacturing tooling to the TM facilities and support set up	*T0+18*

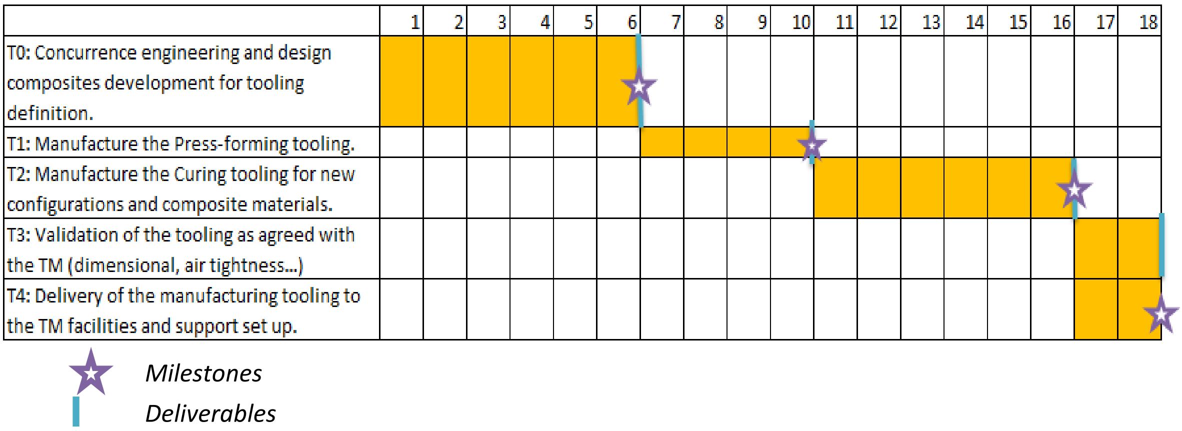
The prototype tooling that will be delivered shall have the following properties:

- 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 heating steps of the cycle.
- 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***
D01	Device specification	R	T0+6
D02	Technical specification press-forming tooling.	R	T0+10
D03	Curing tooling manufactured	H	T0+16
D04	Final report: Conclusions and lesson learned	R	T0+18

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M01	Device and tooling specification	R	T0+6
M02	Device and press-forming tooling manufactured	R	T0+10
M03	Curing tooling manufactured	R	T0+16
M04	Tooling reception	R	T0+18



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

Legend: (M) – Mandatory; (A) – Appreciated

- Experience in design and manufacturing of manufacturing tooling for structures in conventional composite materials and innovative metallic components (M).
- Full mechanizing facilities: milling, finishing, drilling, cutting, electrode erosion,... for all kind of metals and resins. (M)
- Design, simulation capacities and analysis tools of the aeronautical industry: i.e. CATIA v5 r21 (M), NASTRAN (M), VPM (M)
- Experience in management, coordination and development technological (Aeronautical) programs. (M)
- Proved experience in collaborating with reference aeronautical companies. (M)
- Participation in international R&T projects cooperating with industrial partners, institutions, technology centres, universities and OEMs (Original Equipment Manufacturer). (A)
- 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
- Specifically, the applicant must have: (M)
  - Auto-heating tooling development experience.
  - 3D additive manufacturing process.
  - 3D printing capacities in thermoplastic
  - High quality inspection technologies; with light, artificial vision.
  - Injection tooling experience.
  - Automation capacity.
  - Conformal cooling with steel additive manufacturing

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

VII. High Throughput Micro Drilling (HTMD) System

Type of action (RIA or IA)	IA		
Programme Area	LPA, Platform 1, WP1.4.1		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	2 000 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	36 months	**Indicative Start Date**[8]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-LPA-01-24	**High Throughput Micro Drilling (HTMD) System**
Short description (3 lines)	
Design and manufacturing of a prototype machine to microperforate holes between 50 and 100 micra of diameter in large Titanium sheets with high throughput and rate (up to 300 hole/second) to be tested on an industrial environment (up to TRL-6).	

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

1. Background

Aligned with Clean Sky2 objectives, LPA IADP – WP 1.4 intends to apply the Hybrid Laminar Flow Control (HLFC) technology on large scale demonstration campaigns.

Inside WP1.4.1 _ HLFC an improved Hybrid Laminar Flow Controlled (HLFC) Leading Edge for a Horizontal Stabilizer (HTP) will be developed and manufactured.

This topic aims to support the development of this HLFC technology by solving one of its main problems and challenges; the lack of industrial solutions for micro perforation of titanium on large panels.

Although high rate microdrilling of Titanium in small samples can be performed with different laser strategies, as it has been demonstrated during the initial phases of this project, there are no existing solutions for scaling up this technology on large machines with high throughput.
In-process quality control and process control system must be developed to assure that required micro-hole dimensions and location are maintained on tolerances inside all work area and during large process times.
Strategies for avoid deformation of the titanium sheet during the micro perforation process represents also an important challenge of this topic.
So, the objective of this project is to assess the feasibility of the micro drilling of large panels by designing and manufacturing a prototype machine and testing it on a relevant industrial environment (TRL 6).

Based on process development performed by the topic manager the applicant will have to design and manufacture a micro drilling machine prototype with the following characteristics:

- Micro perforation of holes of diameter of 50 to 100 µm on Titanium sheets of 0,5 to 1 mm thickness.
- Micro perforation of large panels up to 5000 x 2000 mm.
- Micro perforation rate from 300 to 500 holes per second.
- In process quality controls for assuring micro perforation quality.
- Head and supports design for minimizing the titanium sheet deformation.

The main deliverable of this CfP will be the prototype machine adjusted and optimized for the manufacturing of microperforated panels required for HLFC HTP demonstrator.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 1	Process selection and optimization. Specification of the micro-drilling process technology and process parameters. Cycle time and quality parameters.	T0+2
Task 2	HTMD system design	T0+8

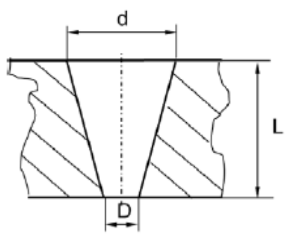
Tasks		
Ref. No.	***Title - Description***	***Due Date***
	Preliminary design of the HTMD system, definition of the number and position of the micro-drilling heads, feeding system, in-process quality control and process monitoring. Fulfilling of the specifications. Detailed design.	
Task 3	HTMD system manufacturing, assembly and testing, including the commissioning and acceptance tests.	T0+24
Task 4	HTMD system optimization.	T0+36

This topic starts from the definition of the geometry, micro-holes distribution, panel structural definition done by the Topic Manager in previous activities of CS2_WP1.4.1 _ HLFC-HTP. All this geometrical and structural specifications are defined in order to fulfil the final requirement of optimal drag performance. Other additional features of the surface, which improves its performance, shall be proposed and defined by the applicant (such as super-hydrophobic anti–ice behavior).

Also the Topic Manager shall define the estimated cycle time to reach productivity figures similar to the ones accepted by the industry.

Applicant shall present a thorough state of the art analysis of alternative technologies, and will explain advantages and drawbacks of each of them. He will then explain which are the preferred envisaged technologies based on well-chosen list of criteria defined by the applicant himself. The final choice will be made at the beginning of the project (task 1) in agreement with the topic manager.. The proposed technology shall allow the fulfilment of the whole specifications defined by the Topic Manager, which will include their scalability over curved surfaces, the residual stresses condition, and the heat affected zone.

This state of the art analysis, completed by one or two envisaged solution shall be included in the applicant's proposal.

Micro-holes dimensional requirements (Provisional - TBD by Topic Manager)		
Ti (grade 2) sheet Thickness:	0,8 mm (L)	
Distance between holes (Pitch)	0,5- 0,7mm, squared grid	
Entrance diameter (d)	85- 125um	
Exit diameter (D)	50- 70um	

Task 1: Process selection and optimization

Starting from the specification of the panels, and taking into account microdrilling process developments already performed in CS2_WP1.4.1 _ HLFC-HTP, the applicant shall propose the most suitable manufacturing technology for high throughput micro-drilling process, and demonstrate its ability by producing some samples

(size to be defined) in titanium plates. A single process shall be defined, and this task will be devoted to the optimization of such process. Process parameters and strategies will be defined according to other engineering requirements like plate material and thickness; size, roundness, tapper of the microholes; process sequence, i.e. micro drilling over flat plates or over final part; final stress condition, etc.
Conclusion of Task 1 shall be a milestone defining the optimum process conditions for the prototype manufacturing, as well as the final industrial parameters for serial production of the micro drilled parts.

Task 2: HTMD system design

The term system refers to a complete production system around the production machine itself. Obviously the machine design is included in this task, but also it shall be defined the feeding system for the titanium plates, the clamping system in order to assure the referencing of the plates, cooling, monitoring of the process for quality control purpose, surface cleaning methods, and in process quality control.
Starting from the matrix of specifications provided by the Topic Manager, the task is divided in 2 subtasks, the first one shall end with a Preliminary Design Review. The purpose of the PDR is to have certainty about the fulfillment of the specification matrix. After PDR, the Detailed Design Review subtask will start, which will end with the manufacturing drawings and materials list. A DDR shall take place before launching the manufacturing of the system. After DDR a clear fulfillment of the specification matrix shall be achieved.
The approved design shall allow the further definition of a system for the industrial production of similar plates. All critical issues shall be covered in this prototype system, in such way that further industrialization should be a scalability issue.

Task 3: HTMD system manufacturing, assembly and testing

This task includes all the activities required for the manufacturing of the HTMD system, its assembly, testing and commissioning at Topic manager facilities. The fulfillment of the specification matrix shall be verified by means of acceptance tests defined in the previous task.

Task 4: HTMD system optimization

HTMD system will be tested on real work condition for the manufacturing of micro perforated panels for HLFC demonstrator and other test panels.
Process conditions will be the same than final industrial parameters, and shall be defined in Task 1. Three panels shall be delivered, so the amount of panels to be produced shall be enough to check the repeatability of the process, and shall be defined by the applicant. It is expected the fabrication of several full parts to validate the process, and some other parts (to be defined) to validate the product.
At the end of this task the Applicant will issue a report describing the main problems of the prototype machine and the opportunities for the design of new microdrilling machines.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Specification of the manufacturing process parameters	Report	T0+2
D2	Samples produced with the selected manufacturing processes	Samples	T0+2
D3	Preliminary design of the production system	3D drawings	T0+5
D4	Matrix of fulfilment of the specifications (v1)	Report	T0+5
D5	Preliminary design of the production system	3D drawings	T0+8
D6	Matrix of fulfilment of the specifications (v2)	Report	T0+8
D7	Manufacturing system ready for panel production	Production system	T0+24
D8	Micro-drilled panels ready for inspection and testing (validation of the prototype machine)	Panels	T0+26
D9	Performance problems and opportunities for design future microdrilling machines.	Report	T0+36

Milestones			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Process validation		T0+2
M2	Preliminary design review (PDR)		T0+5
M3	Detailed design review (DDR)		T0+8
M4	Manufacturing system acceptance		T0+24
M5	Micro-drilled panels for demonstrator available		T0+26

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

It is expected that the previous experience and background of the applicant is adequate to have a benchmarking of alternative processes. State of the art analysis shall be based firstly on own background.. In particular, micro EDM, pulsed micro ECM, e-beam micro drilling and some laser based alternatives shall be included among the documented experience of the applicant.

It is also expected that the applicant has previous experience and background in the design, manufacturing, assembly and commissioning of innovative production systems, which integrate novel manufacturing processes with in process-line quality control methods.

It is also expected that the applicant has previous experience and background in the monitoring and control of manufacturing processes in general, and specifically in high energy density processes. Also it is valuable experience in optical design of guiding systems for manufacturing application. Finally, as additional and complementary functionalities of the surface are also valuable, previous experience and background in surface technologies are appreciated, non-destructive characterization methods, as well as robotics application for automation of manufacturing processes.

Specifically the applicant should have:

- A thorough understanding and demonstrated competence in the area of high energy density manufacturing processes, in innovative production systems, in in-process quality control, and in monitoring manufacturing processes.
- Previous experience in high throughput micro-drilling of titanium panels.
- A demonstrated ability to protect new intellectual property and avoid conflict with existing IPR.
- A demonstrated ability to industrialize developed technology related with surface manufacturing processes.
- A demonstrated experience from collaborative R&D of manufacturing technologies within European projects.

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

VIII. Ground Based Systems Demonstrator: Development, manufacturing and testing of a smart amplifier and a control box for fluidic actuators with advanced monitoring capabilities

Type of action (RIA or IA)	IA		
Programme Area	LPA, Platform 1, WP1.5		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	500 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	24 months	**Indicative Start Date**[9]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-LPA-01-25	**Ground Based Systems Demonstrator: Development, manufacturing and testing of a smart amplifier and a control box for fluidic actuators with advanced monitoring capabilities**
Short description (3 lines)	
For the qualification of AFC (Active Flow Control) systems for application on the pylon wing junction, wind tunnel test (W/T) and ground test (GT) campaigns will be performed using actuator systems based on piezoelectric transducer elements. One essential part of such an actuator system is a drive and control unit that can be used to drive and control full-scale actuators in a relevant environment during these test campaigns. The development work is focusing on the actuator hardware control as well as on the capability to integrate these low-level control systems in higher control levels.	

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

1. Background

The desire for both more ecologic and 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 challenging when novel aircraft configurations are considered, for which highly integrated Ultra High Bypass Ratio (UHBR) engines are considered.

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 aircrafts, 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 more ecologic UHBR engines, slat-cut-outs will likely become larger and the problem will even become worse.

To compensate this drawback Active Flow Control (AFC) based on pulsed air blowing with and without net mass flux, could be applied at the engine-wing junction. To enable AFC, actuators are necessary that satisfy the challenging requirements in the aforementioned areas of application. Actuators for active flow control (AFC) are systems with powered mechanical elements enabling an unsteady manipulation of the airfoil's boundary layer. Such actuators need a special design, which is based, in the present case of synthetic jet actuators and pulsed jet actuators, on a piezoelectric transducers concept.

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

2. Scope of work

Activities to be performed by the applicant:

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

For the qualification of AFC systems for application on the pylon wing junction, wind tunnel test (W/T) and scale 1 ground test (GT) campaigns will be performed. The development work within the work packages is focusing on the actuator hardware control as well as the capability to integrate these systems in higher control levels. One essential part of such an actuator system is a drive and control unit that can be used to drive and control full-scale actuators in a relevant environment during a ground test campaign.

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

- driving module to drive actuators based on piezoelectric bender structures at application specific driving voltages, an integrated amplifier solution is preferred
- control unit to provide the relevant signal (amplitude, signal form, frequency) for the actuators
- sensor data acquisition unit that can handle the sensor data of one or a set of actuators enabling the control of the actuator or even health monitoring of the actuator during operation
- communication unit that can be used to remotely drive and control the actuators from a distance that is relevant in a larger scale or even full-scale WTT respectively.

Task 1: Drive and control system concept

The main objective of this task is the development of the smart amplifier and the control box for fluidic actuators.

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

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

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

- Capacity of the piezoelectric transducer up to 200 nF per single element
- Capability to drive and control >100 actuators (exact number of actuators will be defined during the definition phase in the first part of the project)
- Driving Voltage up to 200 Vpp; preferably unipolar driven, optionally bipolar driven

- Driving Frequency up to 4 kHz (depending on the application and the actuation concept)
- Minimal space allocation – an integrated solution should be preferred
- Minimal energy consumption or a concept to minimize the energy consumption of a system with multiple control units

Additional features are:

- Monitoring of the open system parameters using a smart device
- Implementation of advanced monitoring interface system
- Option to implement control algorithms for AFC actuators

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

The outcome of task one is a conceptual study that can be reviewed based on the requirements coming from CS2 partners planning the ground test campaigns. The approved concept will be input for task 2.

Task 2: Development of a demonstrator (hardware) and manufacturing

Task 2 deals with the manufacturing of the whole control box and its sub-systems. This will include the manufacture or procurement of:

- Smart amplifier system (consisting of: driving module, control unit, sensor data acquisition unit and communication unit) and a suitable housing solution
- Actuator connection panel for a multiple number of single actuators

The final setup consists of two sets of boxes for a large scale ground test.

Task 3: Lab testing with actuators

The final drive and control hardware of task 2 shall be tested in a relevant environment. Main objective is the validation of the functionality for the given system specifications listed in task 1 as well as the proof of functionality with scale one actuators. Full-scale actuators will be provided by the Clean Sky 2 LPA partners.

3. Major deliverables/ Milestones and schedule (estimate)

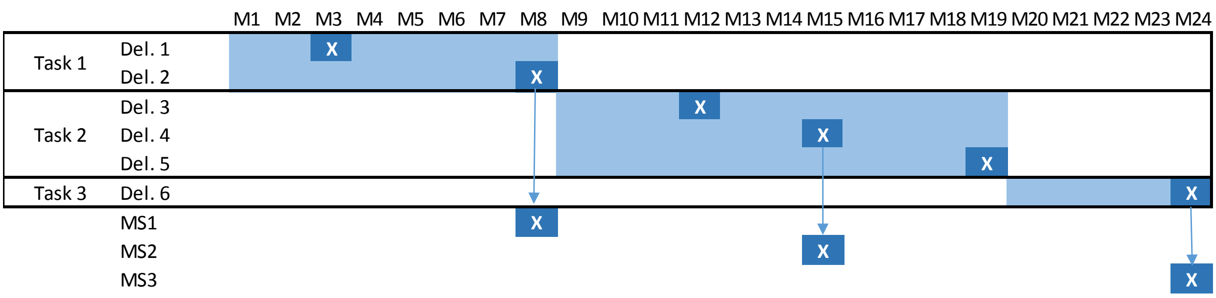
Major deliverables and milestones are summarized in the following tables:

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***

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

Milestones		
Ref. No.	***Title - Description***	***Due Date***
MS1	**SAB Design Review**	**M8**
MS2	**SAB Integration Review**	**M15**
MS3	**Hardware Delivery**	**M24**

Proposed Timetable



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

- The applicant should have expertise in the area of development of power electronics for piezoelectric actuators or transducer, especially in the field of high frequency actuation
- The applicant should have expertise in the area integrated electronics as an integrated power supply solution should be preferred
- The applicant should have expertise in the field of Sensor- and Embedded Electronics as well as Integrated High Voltage Electronics

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

IX. Design, Build and Test Innovative Actuation Concepts for Separation Flow Control

Type of action (RIA or IA)	RIA		
Programme Area	LPA, Platform 1, WP1.5.3		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	700 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	36 months	**Indicative Start Date**[10]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-LPA-01-26	**Design, Build and Test Innovative Actuation Concepts for Separation Flow Control**
Short description (3 lines)	
The objective is to use preferably existing flow control concepts in combination with each other and/or in innovative arrangements to achieve better aerodynamic effectiveness or system efficiency. The concepts will be studied with numerical simulations and as prototypes in experiments on a generic configuration showing similar flow physics as the engine/pylon configuration. After a successful validation the most promising actuation concepts should be tested integrated as real-scale prototypes into a large WT model representative for the engine/pylon configuration at realistic Reynolds number to give prove about the results in an industrial environment.	

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

1. Background

Active Flow Control (AFC) has shown considerable potential to reduce or suppress flow separation. This potential can be exploited to enhance aircraft performance: increase of lift, increase of lift-to-drag ratio, reduction of noise, vibration, loads etc. To achieve an overall net benefit on aircraft level, the active flow control system's fixed mass and its power-offtake are to be accounted for. These features are predominantly driven by the actuation concept.
The actuation concept is defined by the types of actuators and by how the actuators are arranged. Commonly used actuators are pulsed jet actuators with or without net mass flux, plasma actuators etc. Depending on the actuator, actuation can be steady or unsteady. Characterizing parameters are the momentum coefficient, the actuation frequency, the outlet geometry and size, the outlet angles with respect to the different axis etc. The actuator can be arranged in one line or in grids. For both arrangements actuators might interact which each other and not only with outer flow. Linear arrangements with actuators of a single type have been studied in many studies.
Promising in terms aerodynamic effectiveness up to industrially relevant Reynolds and Mach numbers are pulsed jet actuators with air net mass flux. However the air net mass flux has to be generated on the aircraft which is associated with an introduction of additional system mass and fuel consumption during system's operation. Furthermore, for all actuators the global picture must be considered where also maintenance, safety etc. are of relevance. All these aspects potentially curtail the overall benefit.
The background of this topic is therefore to open the door for new not yet highly matured actuation concepts in the hope of finding innovative solutions with a higher aircraft net benefit than the matured and already considered solutions in LPA Platform 1.

2. Scope of work

The partner has to propose innovative actuation concepts and demonstrate their unique selling proposition to be able to achieve higher net benefits on aircraft level.

As input a baseline configuration consisting of a fuselage, wing, turbofan engine nacelle and highlift system will be given to the partner including the flow conditions in terms of Reynolds number and Mach number. The partner has to aerodynamically characterize this baseline configuration without flow control and then work out innovative actuation concepts to overcome the flow separation. This actuation concept must be profoundly analyzed, understood and validated with numerical and experimental testing. The partner will build a generic configuration like an extruded 2D or 2.5D airfoil consisting of a main element and a flap. This generic configuration should have similar pressure distributions as the baseline configuration. Based on the generic configuration the innovative actuation concept will be investigated and optimized.

The optimized actuation concept will be then developed and manufactured at aircraft scale. The aircraft scale actuators are to be tested in wind tunnel model based on the baseline configuration. Wind tunnel tests at a large model scale and at industrially relevant flow conditions given by high Reynolds number and Mach number will give an aerodynamic proof of concept (Technology Readiness Level 3). The wind tunnel test should also encompass re-testing of the matured actuators already under development in LPA. This will serve as performance benchmark and offers the possibility to validate potential improvements gained from on-going optimization processes.

The work is grouped into the following tasks:

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T1	Design and building of generic wind tunnel model	M4
T2	Wind tunnel testing for generic model and flow	M6
T3	Development and design of innovative flow control concepts	M14
T4	Design and manufacture of flow control prototypes	M18
T5	Wind tunnel testing of innovative flow control concepts installed in the generic wind tunnel model	M22
T6	Analysis of wind tunnel results and optimization of actuation system	M24
T7	Design and manufacturing of a real-scale actuators for baseline configuration wind tunnel model	M28
T8	Wind tunnel validation of innovative actuation concept on baseline configuration	M31
T9	Analysis of flow control results obtained in wind tunnel tests with baseline configuration under realistic Re and Ma	M35

Task 1: Design and building of generic wind tunnel model
The applicant has to design and manufacture a wind tunnel model that is suitable to represent the typical flow separation phenomena and mechanisms associated with the close-coupling of large engines to the wing. The typical flow separation phenomenon at low speed (Mach number ~0.15…0.2) and landing is characterized by a separation located at the engine-pylon. A limited separation located at the wing leading edge usually already occurs at low angles of attack. This leading edge separation combines with a trailing edge separation moving forward with increasing angle of attack. The applicant should use a simple, preferably existing wind tunnel aerofoil (e.g. a two element aerofoil configuration) and modify the model via adaptations and modifications to be representative to the aforementioned described key flow phenomena. Simple wind tunnel aerofoils are a common inventory object of almost all wind tunnel facilities. For successful applicants not in the possession of such a model, the topic manager will of course provide a suitable geometry which the applicant can use to create the necessary model.

Task 2: Wind tunnel testing for generic model and flow
In a wind tunnel test the applicant validates and shows that the baseline flow is representative compared to what has been described under Task 1. Representativeness can be only provided when Reynolds number is over 1Mio based on the Mean Aerodynamic Chord (MAC) of the wing/aerofoil. The validation encompasses a clear visualization of the flow problem in space and time. The applicant furthermore uses the experiment to identify innovative flow control actuators or actuation concepts.

Task 3: Development and design of innovative flow control concepts

Based on the previous task and based on a system specification (installation space, max available air mass flow, max available electric power, etc.) provided by the topic manager the applicant develops and designs innovative flow control concepts. Innovative in this case means that compared to single lane actuation based on pulsed jets with and without air net mass flux, the innovative concepts are expected to have a significant advantage in terms of the following technology evaluation criteria

- System mass,
- System reliability
- System power consumption
- Aerodynamic benefit expressed by lift increase /flow separation reduction

This is only possible by fully understanding flow phenomena while identifying and exploiting interaction leveraging effects between the actuator jets and the outer flow. A benchmark study to the single lane actuation must be provided by the applicant to clearly show the benefit . Open loop and closed-loop control concepts should be considered. The solution selection will be accompanied by the topic manager to ensure the industrial applicability. The development work can be done with numerical simulations as well as with wind tunnel testing. Flow conditions must be industrially relevant and will be provided by the topic manager.

Task 4: Design and manufacture of flow control prototypes

Following the previous task, the applicant will design and manufacture the prototypes and install them into the generic wind tunnel model. Some pre-testing will be conducted to characterize the actuators in silent conditions.

Task 5: Wind tunnel testing of innovative flow control concepts installed in the generic wind tunnel model

The applicant tests the innovative flow control concepts open-loop and closed-loop based in a wind tunnel. Measurement techniques should be the same as for Task 2 and must allow a quantification of the aerodynamic benefit thanks to flow control. Measurement should enable a correlation of system mass and power consumption and their sensitivity on the aerodynamic benefit. For the tests the Reynolds number with respect to the mean aerodynamic chord should be at least 1.5Mio and the free flow should be at least M=0.15.

Task 6: Analysis of wind tunnel results and optimization of actuation system

Results of the wind tunnel tests are analysed profoundly. The actuation concepts are optimized which might take several iterations with Task5.

Task 7: Design and manufacturing of real-scale actuators for baseline configuration wind tunnel model

After reflection of the experiment and a decision gate with the topic manager the applicant designs and manufactures an aircraft-scale prototype of the actuator/actuation concept. This actuator is dedicated to the baseline wind tunnel model. The baseline wind tunnel model should consist of a swept wing in highlift configuration with though-flow-nacelle attached to the wing by a pylon. Preferably a baseline wind tunnel model according to the descriptions before is existing and in the possession of the partner/partner consortium. If the successful applicant does not possess the necessary wind tunnel model, the topic manager will provide the wind tunnel model to allow the applicant to design and manufacture a baseline wind tunnel model.

Task 8: Wind tunnel validation of innovative actuation concept on baseline configuration
The innovative actuation concept is validated as installed the baseline configuration wind tunnel model at realistic model scale and industrially relevant flow conditions given by Reynolds number and Mach number. For the tests the Reynolds number with respect to the mean aerodynamic chord should be at least 6Mio and the free flow should be at least M=0.15.

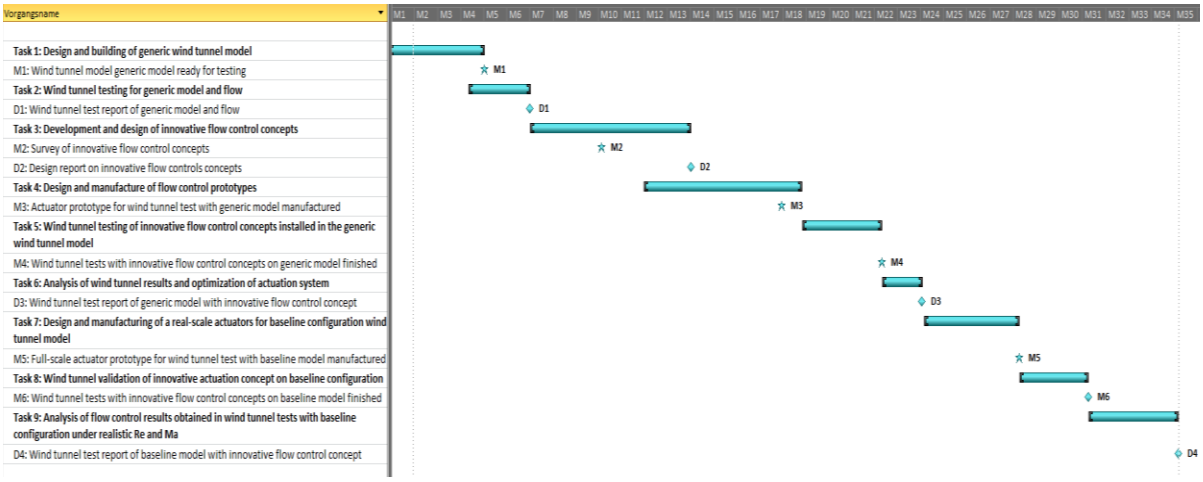
Task 9: Analysis of flow control results obtained in wind tunnel tests with baseline configuration under realistic Re and Ma
Wind tunnel results are analysed and results are handed over together with information on the technology evaluation criteria defined in Task 3 to the industrial partners for an evaluation on aircraft level.

3. Major deliverables/ Milestones and schedule (estimate)

Ref. Nr.	Deliverable Title -	Type	Due date
D1	Wind tunnel test report of generic model and flow	Report	M6
D2	Design report on innovative flow controls concepts	Report	M14
D3	Wind tunnel test report of generic model with innovative flow control concept	Report	M24
D4	Wind tunnel test report of baseline model with innovative flow control concept	Report	M35

Ref. Nr.	Milestone Title	Type	Due date
M1	Wind tunnel model generic model ready for testing	Hardware	M4
M2	Survey of innovative flow control concepts	Presentation	M10
M3	Actuator prototype for wind tunnel test with generic model manufactured	Hardware	M18
M4	Wind tunnel tests with innovative flow control concepts on generic model finished	Presentation	M22
M5	Full-scale actuator prototype for wind tunnel test with baseline model manufactured	Hardware	M28
M6	Wind tunnel tests with innovative flow control concepts on baseline model finished	Presentation	M31

Visualisation of tasks, deliverables and milestones in a simplified Gantt Chart



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

The applicant must demonstrate profound knowledge and expertise

- In aircraft highlift aerodynamics incl. flow separation phenomena and triggering effects (preferably also for the engine/pylon application case)
- In all common active flow separation control principles, such as pulsed, continous air blowing and/or suction, including their interaction with the outer flow (preferably proven by a track record of publication in the relevant flow control aspects)
- In the combination of different flow control principles (at least two) to exploit leveraging and/or interaction effects.
- In the development and design of flow control actuators with and without air net mass flux, in particular also in exploiting jet amplitude modulation via non-harmonic waveforms for jet actuation
- In testing and charterization flow control actuators in silent and crossflow conditions with laboratory and real-scale hardware
- In the range of fabrication approaches that are cost effective and proven for flow control actuators (3D printing, milling etc.)
- In wind tunnel model design, manufacturing and modifcation
- In wind tunnel testing, flow visualisation, data measurements and data postprocessing/analysis
- In preparing, conducting and postprocessing high-fidelity numerical flow simulations (e.g. URANS)

The applicant must have access to

- A wind tunnel facility to conduct the test on the generic configuration (e.g. two element airfoil) at a Reynolds number of 1.5 Mio wrt to the mean aerodynamic chord and a Mach number of at least 0.15
- A wind tunnel facility to conduct the test on the baseline configuration swept wing with engine/pylon and flow-through-nacelle at a Reynolds number of above 6 Mio wrt to the mean aerodynamic chord and a Mach number of at least 0.15
- The high performance computing resources necessary to perform time-resolved simulations of at least Unsteady Reynolds-Averaged Navier Stokes (RANS) quality; explicit time resolution of unsteady jet

actuation is not mandatory but if models are used, a comprehensive proof must be given that the model works in 2D and 3D flows and must account for the effect of jet actuation frequency.

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

X. Development of scaled models for Synthetic Jet Actuators (SJA) based on Aerodynamic Characterization in CFD, Ground and Wind Tunnel Testing

Type of action (RIA or IA)	RIA		
Programme Area	LPA, Platform 1, WP1.5		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	600 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	36 months	**Indicative Start Date**[11]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-LPA-01-27	**Development of scaled models for Synthetic Jet Actuators based on Aerodynamic Characterization in CFD, Ground and Wind Tunnel Testing**
Short description (3 lines)	
High fidelity numerical simulations will be used to characterize the synthetic jet actuators. The CFD data will be validated by ground tests (w/o cross flow) and wind tunnel tests (with cross flow). The results of the numerical simulations will be used to develop scale models for performance estimation and calculation of geometrical design parameters of the actuators.	

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

1. Background

The desire for both more ecologic and 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 challenging when novel aircraft configurations are considered, for which highly integrated Ultra High Bypass Ratio (UHBR) engines are considered.
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 aircrafts, 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 more ecologic UHBR engines, slat-cut-outs will likely become larger and the problem will even become worse.
To compensate this drawback Active Flow Control (AFC) based on pulsed air blowing with and without net mass flux, could be applied at the engine-wing junction.
For Synthetic Jet actuator systems generating pulsed air without net mass flux, the correlation between actuation mechanics and actuated flow is not fully understood yet. In the frame of this topic this correlation will be investigated via high fidelity numerical simulations and laboratory testing.
Based on the correlation a new scale model shall be developed, allowing a detailed understanding of the Synthetic Jet Actuators (SJA). This will enable a fast performance and behavior prediction of the next generation of SJA.

2. Scope of work

In this context the objective is to develop scale models for the synthetic jet actuators, based on high fidelity numerical simulations, and validated by means of ground and wind tunnel tests. All related expertise, experience and tools expected from the partner are presented in this section.
The following tasks have to be performed by the applicant:

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T1	High fidelity numerical simulations of existing SJA prototype designs in quiescent air condition	M10
T2	Experimental testing of actuator prototypes in quiescent air condition.	M12
T3	Comparison of numerical and experimental results and modelling of the system.	M15
T4	High fidelity numerical simulations of existing SJA prototype designs in cross flow condition.	M18
T5	Experimental testing of actuator prototypes in cross flow conditions	M20
T6	Comparison of numerical and experimental results and modelling of the system.	M24
T7	Development of scale model for the synthetic jet actuators based on the validated CFD and test results for quiescent air (T3) and cross-flow condition (T6).	M30
T8	Verification of scale model in the design of a new SJA	M36

Task 1: High fidelity numerical simulations of existing SJA prototype designs in quiescent air condition

The applicant should set up, conduct and evaluate high fidelity numerical, time accurate simulation of synthetic jet actuators. Using geometrical data delivered by the supplier of synthetic jet actuators (SJA), the applicant will set up and conduct a first loop of CFD simulations with the first design of a SJA.

In the proposal, the applicant will explain the numerical tools used for the simulation. The applied numerical tools for the simulation have to be agreed by the topic manager.

The operating conditions of the SJA will be delivered in advance: frequency, max. amplitude of the piezo membrane, time resolved position of the piezo membrane.

The maximum operating frequency of the SJA will be in the range of 1-2kHz.

To validate the quality of the numerical simulations, the CFD results of the first loop (first SJA design) will be validated by the comparison with data already available from the manufacturer of the SJA (tbc), or with data coming from the ground test results of the first SJA design.

Numerical simulations will be conducted for SJA design with different geometrical configurations, which will be delivered to the applicant by the topic manager.

Task 2: Experimental testing of actuator prototypes in quiescent air condition

The applicant should perform lab tests with the same configuration and design as used for the first numerical simulations. Lab test means, the SJA will be tested without free stream flow, only in quiescent air condition.

The test should take into consideration time resolved velocity measurement of SJ flow leaving the nozzle, time resolved pressure measurement inside the cavity of the actuator and temperature values inside the SJA cavity.

The ground test will include several runs, with (at least) two different geometrical configurations of the SJA. The actuators hardware as well as the driving power electronics will be delivered to the applicant by the topic manager.

Task 3: Comparison of numerical and experimental results and modelling of the system

The applicant should perform a detailed analysis of the numerical and experimental results.

Based on these results the system of the SJA can be modelled on different layers. Starting with a black box model the applicant should develop a detailed model, which includes as much physical system aspects as possible. A detailed model of the system is an essential part for the scale models.

Task 4: High fidelity numerical simulations of existing SJA prototype designs in cross flow condition

Within T1-T3 the actuator behavior was considered with reduced complexity, to have a good starting point and have the possibility to develop the models step by step. Within this task, the applicant should extend the CFD simulations of T1 with a cross flow over the nozzle of the actuator. This is the real environment of the actuator.

Task 5: Experimental testing of actuator prototypes in cross flow conditions

Wind tunnel tests will be carried out with (at least) two different SJA configurations, the same used for the lab tests. There will be a variation of freestream velocity (Ma=0.1, 0.2, 0.25) and outer pressure conditions.

The test should comprise time resolved velocity measurement of SJ flow leaving the nozzle, time resolved pressure measurement inside the cavity of the actuator and temperature values inside the SJA cavity.

The experimental setup will be defined together with the consortium using a wing (2D) or a flat plate with the opportunity to change the local pressure at the exhaust of the SJA.

Task 6: Comparison of numerical and experimental results and modelling of the system.

Similar to T3, the applicant should perform a detailed analysis of the numerical and experimental results.

Based on these results and the work in T3, the system of the SJA can be modelled on different layers. Starting with a black box model the applicant should develop a detailed model, which includes as much physical system aspects as possible. A detailed model of the system is an essential part for the scale models.

Task 7: Development of scale model for the synthetic jet actuators based on the validated CFD and test results for quiescent air (T3) and cross-flow condition (T6).

Based on the numerical simulations, a scale model for the SJAs has to be developed. The validation of this model requires the usage of numerical and experimental data from the tests in T3 and T6.

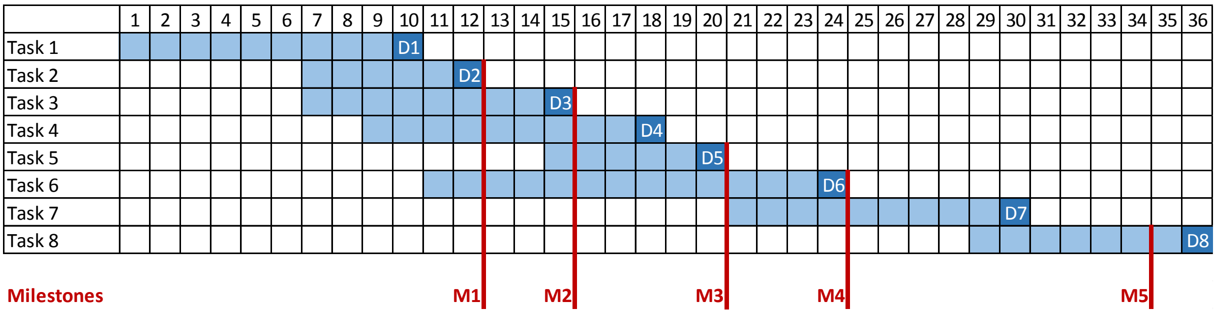
Scale model means a model, which make it possible to extract the estimated performance of the actuator configuration by input of the geometrical parameters and the parameters of the transducer element.

It takes into account the influence of the used geometrical and electrical parameters to the needed drive electronic system and can be used as representative for numerical models. This allows the understanding of SJAs and a fast performance prediction of next generation SJA. Additional the scale model can be used for calculations of the benefit of using SJA for AFC in aircraft applications.

Task 8: Verification of scale model in the design of a new SJA

The new scale model will be used to enable the design of the next generation SJA. The verification of the scale model will be performed in close cooperation between the application and the topic manger by designing and characterizing a new actuator based on the findings using the model. The characterization of the actuator will give a first feedback on the accuracy of the model.

3. Major deliverables/ Milestones and schedule (estimate)



Ref. Nr.	Deliverable Title -	Type	Due date
D1	Analysis of numerical results of SJA in quiescent air condition.	Report	M10
D2	Analysis of experimental results of SJA in quiescent air condition.	Report	M12
D3	Model of SJA in quiescent air condition	Report	M15
D4	Analysis of numerical results of SJA in cross flow condition.	Report	M18
D5	Analysis of experimental results of SJA in quiescent air condition.	Report	M20
D6	Model of SJA in cross flow condition	Report	M24
D7	Scaled model for SJA	Report	M30
D8	SJA scaled model verification	Report	M36

Ref. Nr.	Milestone Title	Type	Due date
M1	Lab test finished		M12
M2	SJA model (quiescent air condition) validated		M15
M3	Wind tunnel test finished		M20
M4	SJA model (cross flow condition) validated		M24
M5	Verification of scale model successful		M34

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

The applicant should have profound knowledge in flow control actuator design for aircraft applications. The actuator design must be based on pulsed air blowing without net mass flux.

- The applicant should have expertise in the area of CFD
- The applicant should have expertise in the area of flow measurements and characterization of fluidic devices
- The applicant should have the possibility to prepare and perform lab tests and WT tests to verify the simulation results
    - This includes: selection of test geometry, integration of sensors, definition of boundary conditions, data acquisition and data handling

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

XI. Divergent Aircraft Configurations

Type of action (RIA or IA)	RIA		
Programme Area	LPA, Platform 1, WP1.6.1.4		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	1 500 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	30 months	**Indicative Start Date**[12]	Q2 2017

Identification	Title
JTI-CS2-2016-CFP04-LPA-01-28	**Divergent Aircraft Configurations**
Short description (3 lines)	
Requested is the delivery of analysis models, of a design platform and of design support for an aircraft design exercise in the field of novel (hybrid) propulsion architectures. The requested know-how comprises system, airframe and operation modelling as well as optimization expertise.	

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

1. Background

Work Package 1.6 of the Large Passenger Aircraft (LPA) IADP is aimed at the Demonstration of Radical Aircraft Configurations. One main topic in this work package is the aircraft configuration development for alternative propulsion concepts. This work is mainly performed in Work Package 1.6.1.4, “Divergent Aircraft Configurations”. Here, advanced aircraft concepts shall be developed based upon a design strategy targeting a perfect synthesis between innovative airframe concepts and a novel propulsion architecture and its comprising individual technologies. The plan is to open a new design and validation space and offer through this approach a set of efficiently developed (time, cost) and validated airframe and propulsion concepts to overcome the threshold to full game-changing aircraft design. To fulfil the intention of work package 1.6, a very high integration level between airframe and propulsion system is required.

Focus of the work in WP 1.6.1.4 is on integration concepts for Hybrid Propulsion, thus going beyond the UHBR and the CROR. The optimal hybrid propulsion architecture with respect to flight mission profiles, based on synergies and opportunities, has to be defined. An investigation of the interactions and limitations of radical aircraft configurations and of projected hybrid energy technologies shall lead to a sound concept.

The existing consortium drives the development of advanced aircraft concepts based upon a team-centred design strategy. The work is performed by two design teams, with a potential third team joining in 2016. These teams each cover the complete range of aircraft conceptual design and will concentrate on different aircraft configurations, respectively. Two common reference aircraft, one with classical turbofan engines, one with turboprop engines, will be a common baseline for all teams. While each team will concentrate on exploring different design regions of novel propulsion and innovative airframe concepts, the investigations are linked by common evaluation criteria. Tools used by all partners include conceptual design tools, preliminary design tools, as well as high fidelity design tools where necessary. Investigations are, by necessity, multi-disciplinary.

A crucial point for the cooperation of the design teams is the availability of common know-how and modelling approaches for aircraft systems, including the blocks for hybrid propulsion systems and for aircraft structures, as well as the availability of a common modelling framework (design platform), for system integration and multidisciplinary analysis and optimisation. The expected level of detail is a conceptual and preliminary design level. This expertise is expected to be contributed by the applicant. The contributions of the applicant shall thus be available for all design teams. Each design team will specify the interfaces of its existing design chains to be supported by the applicant at the start of the activity.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T 1	Advanced structural models and analysis for aircraft concept explorations	M0+30
T 2	Refined on-board system models and analysis for overall aircraft assessments	M0+30
T 3	Operational and mission model and analysis of hybrid electric aircraft	M0+30
T 4	Design platform for analysis and optimization of subsystems and configurations	M0+30

Partners from industry and research work together on the investigation of alternative energy propulsion architectures and components. While the industrial partners concentrate on development and integration of solutions sufficiently mature for a potential application in the next generation of aircraft (a so-called convergent approach), research institutes look at more advanced solutions with a potential to be applied an aircraft generation later for divergent design exercise addressed in this Call for Partners. Thus, contributions by the applicants shall mirror that requirement.

The work will generally be organized in three phases - first, during a definition phase of approximately nine months, interfaces between applicant and the design teams of the core partners will be defined, and processes and models will be specified. In a second phase of approximately twelve months, overlapping with the definition phase, models and design software will be exchanged and matched with the processes of the design teams. Third, in a subsequent simulation and assessment phase, the applicant works together with the design teams in performing analyses and assessing results.

Task 1: Advanced structural models and analysis for aircraft concept explorations

Structural models are a key element of the aircraft models required to assess propulsion integration, integration of energy storage, systems integration, as well as aircraft performance. For this purpose, the structural models have to include wing models, fuselage models, tailplane models, a suitable representation of the engines and the propulsors, in terms of geometry, structural properties (e.g. strength and elasticity) and mass distribution.

The generation of the structural models shall be possible in a short time frame and for a variety of aircraft configurations, as to enable a fast assessment of a wide field of design parameters. The structural models shall be usable for multi-physics analysis, e.g. for fluid-structure-coupling and coupling with external system models. An option of post-processing of the models in standard finite-element-codes (e.g. NASTRAN) is heavily favoured.

The applicant shall use the input of the design teams to develop structural models from conceptual design to preliminary design level. The interfaces to the design environments of the design teams will be agreed upon. Together with the partners in the teams, the influence of hybrid propulsion on structural layout, on structural dynamic properties and on primary aircraft mass shall be evaluated.

T 2: Refined on-board systems model and analysis for overall aircraft assessments

The modelling of aircraft systems is crucial for the evaluation of the influence of hybrid propulsion systems on aircraft configurations. On a conceptual level, this includes for example refined performance and weight models for hybrid propulsion components. Energy consumption of the systems becomes inseparably connected to the energy consumption used directly for propulsion.

The applicant shall work with the design teams in the modelling of aircraft system architecture. The interfaces to the design environments of the design teams will be agreed upon. The applicant shall provide analysis models to the design tasks on the partners. A model format compatible with the design environments of the design teams (e.g. using CPACS) is heavily favoured.

For the selected configurations, the applicant shall conduct performance analysis with focus on energy consumption of the systems and the whole aircraft. Aircraft specifications and model components are provided by the partners. Cross-coupling effects between different systems and sub-systems shall be identified and evaluated. The results are assessed together with the partners in the teams.

T 3: Operational and mission model and analysis of hybrid electric aircraft

The potential benefit of hybrid vs. classical propulsion is directly linked to the mission of the aircraft to be regarded. As an example, for a potential combination of classical propulsion supported by electric motors, the optimal ratio of power supplied by the two types of propulsion is dependent of the mission for which the aircraft is designed. For such an investigation, models of classical engines, electric propulsion (see here also task T 2), as well as of flight mechanics and mission analysis have to be available. As a prerequisite, it has to be guaranteed that the aircraft configuration resulting from the integration studies and optimization is feasible in terms of flight mechanics and handling qualities.

The applicant shall provide models of hybrid propulsion components as well as for the influence of hybrid propulsion and hybrid propulsion systems on flight mechanics and handling qualities. The interfaces to the design environments of the design teams will be agreed upon. The applicant shall develop a module for mission-dependent optimization of combined standard / electric propulsion. The applicant shall, together with the design teams, perform mission-dependent optimizations and assessments for selected aircraft concepts, both for the initial reference configurations and for the final selected most promising hybrid propulsion configurations. Aircraft specifications and model components for this task are provided by the partners. Final results are assessed in combination with the design teams.

T 4: Design platform for analysis and optimization of subsystems and configurations

A common platform for system modelling, from fast conceptual design tools to high-fidelity, complex analysis software is required for analysis and optimization of new configurations using hybrid propulsion. The design platform is an expected contribution and shall be delivered to the design teams by the applicant. The platform shall be open to all partners in the duration of the project. The design platform shall include in-depth modelling of the aircraft systems, enabling subsystems and configuration analyses with possible local and global optimizations.

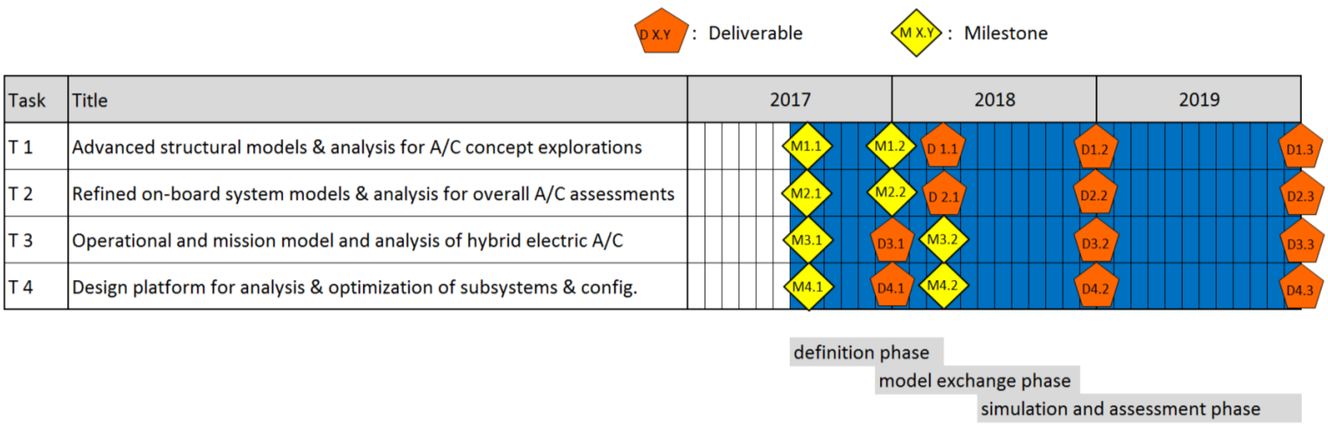
Second, the applicant shall support the partners to set up the definition of selected aircraft reference models using the provided platform. The applicant is expected to perform analysis tasks defined by, and in cooperation with, the core partner design teams. Special emphasis is on optimization tasks for hybrid propulsion integration. The results of the optimizations are assessed together with the partners in the core teams.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 3.1	Operational model of hybrid electric aircraft	Report	T0+6
D 4.1	Design platform for analysis and optimization of subsystems and configurations	Software	T0+6
D 1.1	Advanced structural models and analysis for aircraft concept for first selected reference	Analysis models	T0+9
D 2.1	Models of aircraft systems for overall aircraft assessment for one reference configuration	Analysis models	T0+9
D 1.2	Advanced structural models and analysis for aircraft concept for second selected reference	Analysis models	T0+18
D 2.2	Models of aircraft systems for overall aircraft assessment for second reference configuration	Analysis models	T0+18
D 3.2	Assessment of DLR and ONERA reference configurations	Analysis models	T0+18
D 4.2	Analysis of hybrid propulsion wrt systems on global aircraft level performed for one selected reference	Analysis models	T0+18
D 1.3	Advanced structural models for propulsion integration analyzed for overall design space	Report	T0+30
D 2.3	Aircraft systems for hybrid propuls optimized in overall aircraft assessment	Report	T0+30
D 3.3	Assessment of the down-selected DLR and ONERA most promising configuration	Report	T0+30
D 4.3	Analysis and Optimization wrt systems on global aircraft level performed and evaluated	Report	T0+30

Milestones			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M 1.1	Technical specifications of interfaces with design teams performed	Report	T0+3
M 2.1	Technical specifications of interfaces with design teams performed	Report	T0+3

Milestones			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M 3.1	Technical specifications of interfaces with design teams performed	Report	T0+3
M 4.1	Technical specifications of interfaces with design teams performed	Report	T0+3
M 1.2	Concepts for advanced structural models for aircraft concept explorations documented	Report	T0+6
M 2.2	Concepts for system models for hybrid propusion integration documented	Report	T0+6
M 3.2	Concepts for mission models for aircraft with hybrid electric propulsion available	Report	T0+9
M 4.2	Aircraft system models on design and optimization platform made available	Analysis models	T0+9



4. <u>Special skills, Capabilities, Certification expected from the Applicant(s)</u>

The applicant is expected to have the following expertise:

- A strong background in conceptual aircraft design,
- Experience in development of structural models, from conceptual design to preliminary design level,
- Experience in performing structural analysis,
- Capabilities in the modelling of hybrid propulsion and hybrid propulsion components and systems,
- Knowledge in system modelling, especially those systems related to hybrid and/or electric flight,
- Modelling and assessment capabilities in flight mechanics and handling qualities,
- Modelling and assessment capabilities in operational modelling,
- Background in overall aircraft optimization,
- Background in design software development and application
- Experience with standard (industrial) tools for structure, systems, flight mechanics and aircraft design,
- A track record of cooperation with external design groups in the field of aircraft simulation and design.

XII. Development of a Multi-scale method to predict large aircraft component failure taking into consideration effects of modelling uncertainties

Type of action (RIA or IA)	RIA		
Programme Area	LPA, Platform 2, WP 2.4.3 Predictive Virtual Simulation		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	800 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	36 months	**Indicative Start Date**[13]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-LPA-02-15	**Development of a Multi-scale method to predict large aircraft component failure taking into consideration effects of modelling uncertainties**
Short description (3 lines)	
This research activity will produce an innovative Multi-scale framework enabling the prediction of large aircraft component failure with very high level of accuracy and taking into consideration effects of modelling uncertainties. The new toolbox will be applied to support the development of the Clean Sky 2 demonstrators and be compatible with existing simulation tools.	

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

1. Background

The development will be done in the frame of Clean Sky 2 aiming to maturing and validating disruptive technologies for next generation Large Passenger Aircraft (LPA) through large scale integrated demonstrators.

This topic is related to activities running under the frame of the *Platform 2 Innovative Physical Integration Cabin – System – Structure* oriented to *highly integrated cockpit* and specifically to *WP 2.4.3 Predictive Virtual Simulation* as represented by the work breakdown structure below.

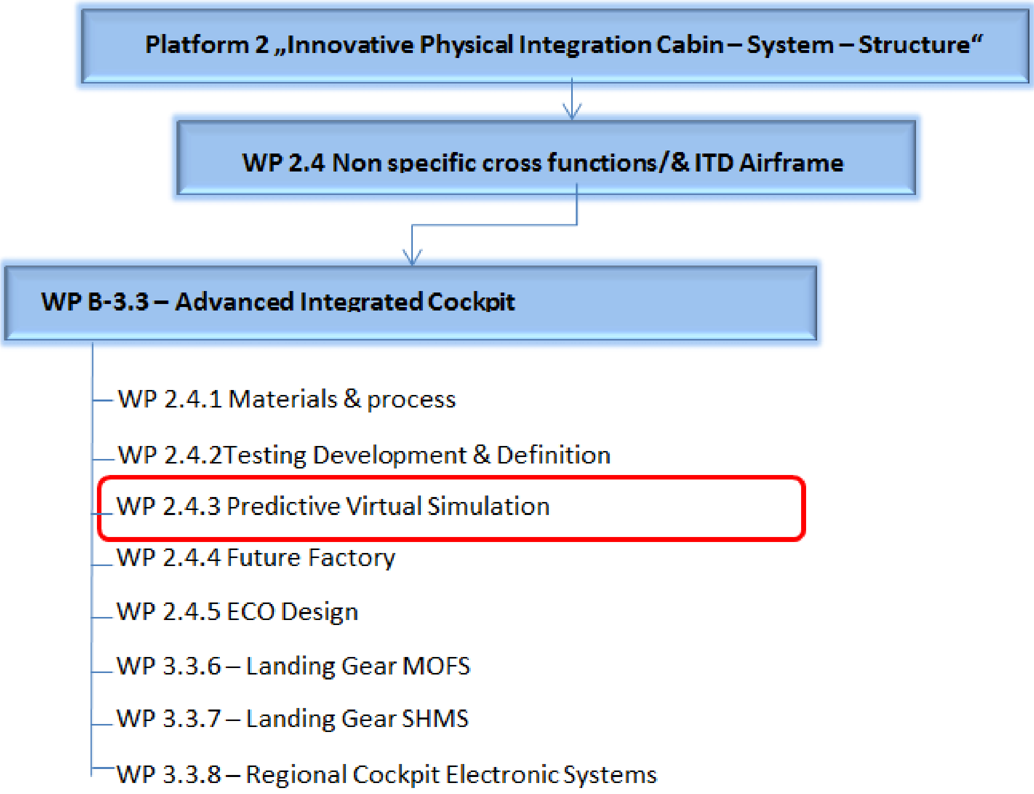


Figure 1 – WBS of Platform 2 „Innovative Physical Integration Cabin – System – Structure“

The project development outcomes will be implemented to the LPA technology demonstrators that will be developed on Platform 2 "Innovative Physical Integration Cabin – System – Structure". The Topic Manager will define beginning of the project the applicable context related to the demonstrators' design, manufacturing and testing for proof of concept.

A first high level objective to which the current topic will contribute is to support aircraft design but also replace physical testing by numerical analyses, namely Predictive Virtual Testing (PVT). A key requirement is that numerical analyses must predict all damages and failures modes at both material and component levels

avoiding any ‘best fit processes’ with experimental data.
A second high level objective is to accelerate the trend towards simulation based Means of Compliance (MoC) with regards to aircraft certification and to promote numerical analysis as a secured certification MoC acknowledged and validated by the civilian Aviation Authorities.
Contributing to the high level objectives above, the current topic is mainly focused on expanding our design space, reducing our development costs and lead time by increasing prediction accuracy, robustness and performance.

The standard modelling techniques developed for aircraft subcomponents certification are generally based on a macro-scale (coarse) due to the large structures considered. This approach allows locating ‘hot spots’, where failure is likely to occur; however, in order to predict accurately modes of damages and failure a refined model will be created in the ‘hot spot’ region. This two-step investigation requires two models and therefore increases man power and lead time.

The multi-scale modelling strategy is an enabler to answer our ever challenging industrial environment where a ‘responsive’ model with short runtimes can provide fast feedback on design validity. The partner(s) will be tasked to develop a robust multi-scale framework allowing running large component models above 1 million elements but still offering the same degree of refinement given to coupon.

2. Scope of work

The scope of work is first to develop a numerical framework linking different levels of modelling refinement in one unique simulation. Three different modelling refinement levels or scales are considered,

- **Micro-scale,** which enables the capturing of damage and failure mechanisms at the material scale; for instance, for metallic materials high mesh refinement (below 0.1mm critical length) allows to capture ‘necking’ mechanism. Such scale is generally used to determine elastic and strength material properties at coupon level only as it requires high Central Processing Unit (CPU) power.
- **Meso-scale**, which is associated with composite materials and where plies and interfaces are represented in the model; such modelling strategy is found to be adequate for composite as it allows to capture both intra- and inter-laminar damage and failure. Such scale can be used to determine elastic and strength properties for small models (below 500,000 elements) only as it required high CPU power.
- **Macro-scale**, which is used for large structural model exhibiting relatively coarse mesh. Such scale is generally used for aircraft subcomponent as it enables to have model to be run on standard High Performance Computing (HPC) with reasonable runtime (below 24hrs). However, CPU efficiency impacts prediction accuracy since material properties have to be calibrated for the coarse mesh. This methodology is highly mesh dependent and lacks important failure mechanisms, such as delamination.

The scope is also addressing the effect of modelling uncertainties; with the use of Uncertainty Quantification and Management, probabilistic methodology, , the partner(s) will provide along with the deterministic prediction its envelope of validity. The applicant(s) will perform an assessment of all the sources of modelling uncertainty (material parameters, material laws, boundary conditions, …) and assess the relative importance of each source of modelling uncertainties on the accuracy of the numerical prediction.

In this context, the applicant(s) will conduct the tasks presented hereafter.

M0: official project start

Tasks		
Ref. No.	***Title – Description***	***Due Date***
1	Multi-scale scale method preselection through current state of the art dedicated to large models	M0
2	Survey on Uncertainties Quantification & Management **methodology implemented** in aircraft predictive virtual simulations	M0 + 3M
3	Modelling strategies determination for micro/meso and macro-scales	M0 + 18M
4	Creation of a new multi-scale framework	M0 + 24M
5	Multi-scale framework implementation to CleanSky 2 demonstrators	M0 + 30M

Task 1: Multi-scale scale method preselection through current state of the art dedicated to large models

The applicant(s) will provide the state of the art and conduct a detailed review of multi-scale methods, such as co-simulation, sub-modelling and sub-cycling. It will be basis for application of thefinal definition to typical sub-assemblies of multifunctional fuselage interfacing with systems.

This review will also pre-select most promising methods to be applied or developed for large aircraft components. It is noteworthy that this review will be part of the proposal background section submitted by the applicant(s).

Task 2: Survey on Uncertainties Quantification and Management methodology implemented in aircraft predictive virtual simulation

The applicant(s) shall perform an assessment of all the sources of modelling uncertainty and assess the relative importance of each source of uncertainty on the accuracy of the numerical prediction. The level of uncertainty that may be expected for each variable considered, with associated scatter should also be addressed to allow a more probabilistic approach to be adopted. A ranking of each source of uncertainty shall be undertaken to illustrate which parameters have the greatest influence.

This survey will be the opportunity to determine and select most appropriate UQ&M methodology to be used in the development of the Multi-scale framework.

Task 3: Modelling strategies for micro/meso and macro-scales

The applicant(s) shall deliver three strategies for the three material scales which will be used in the Multi-scale framework. These methods must be applicable in the context for airframe structural analysis based on considerations such as,

- Ease-of-use
- Availability

- Compatibility with existing tools
- Computational efficiency

Task 4: Creation of a new multi-scale framework

The applicant(s) shall develop a multi-scale framework to allow the use of localized fine-scale models in large structures for composite and metallic failure prediction.

The framework has the following fundamental requirements,

  - As mentioned earlier, certification by numerical analyses is now possible only if heavily supported by test, which increases programme lead time and costs. Reducing testing and have numerical tools as the only MoC is the challenge undertaken within PVS; the multi-scale tool developed by partner(s) will model damage and failure mechanisms in metallic and composite materials. Below is a non-exhaustive list of these mechanisms. Necking of ductile metallic materials
  - Failure of highly orthotropic metallic material
  - Delamination for composite material
  - Matrix micro-cracking for composite materials
  - Compressive failure in fibre direction for composite materials

Note: it is not the purpose of this task to develop methods to simulate these mechanisms.

The supplied multi-scale framework shall enable the following:

- Link between macro-, meso- and micro- scales.
- Capability to host various metallic and composite damage models
- Ability to choose different modelling strategies at fine scale; for instance, for composite modelling a meso-scale model will be needed to ensure delamination modelling
- Ability to host UQ&M algorithm and considerations

Current state of the art of multi-scale techniques are based on two models (fine and coarse scales) and this can result in computational performance issues. An alternative approach is to develop an adaptive meshing technique which will allow running only one model. For instance, delamination crack front can be tracked using fine localized model whereas outside the region of interest a coarse model is used.

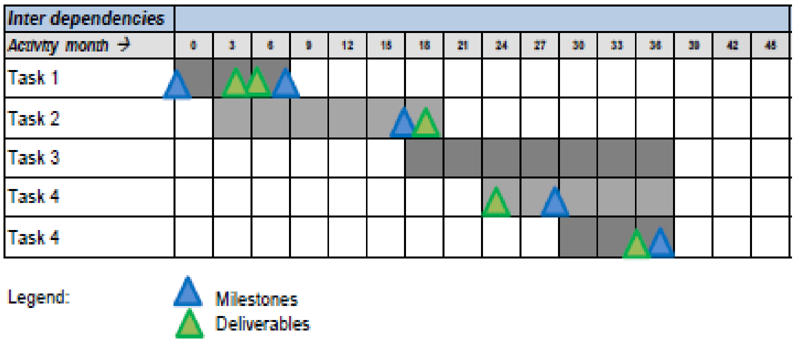
The applicant(s) shall consider the development an automated mesh adaptation algorithm, and associated criteria for fine mesh activation or de-activation as part of this task.

The integration of the uncertainty management considerations into the multi-scale framework represents a high level of innovation.

Task 5: Multi-scale framework implementation to CleanSky 2 demonstrators

The applicant(s) will benchmark and demonstrate the multi-scale framework with the Platform 2 demonstrator that will be selected and defined in corporation with the Topic Manager during Task 1.

The global interdependency between tasks/deliverables/milestones is shown in the here under table:



3. Major deliverables/ Milestones and schedule (estimate)

M0: official project start

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
1	Document describing sources of modelling uncertainties in predictive virtual simulation of aerospace structures and their potential impact on the accuracy results	Report	M0 + 3M
2	Selection of most pertinent multi-scale method in Use in Industry & University and their Applications	Report	M0 + 4M
3	Uncertainty quantification & Management tool	Report + Models + Tools+ User manual	M0 + 18M
4	Delivery of micro/meso and macro-scale strategies & New multi-scale framework	Report + Models + Tools+ User manual	M0 + 24M
5	Results on the application of PVS multi-scale strategy to two CleanSky 2 demonstrators	Report + Models	M0 + 34M

M0: official project start

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
1	Kick-off Meeting	Meeting	M0
2	Multi-scale / UQ&M strategy – Intermediate review	Meeting	M0 + 8M
3	Multi-scale / UQ&M strategy – Intermediate review	Meeting	M0 + 16M
4	Multi-scale / UQ&M adaptation to CleanSky 2 demonstrators – Intermediate review	Meeting	M0 + 28M
5	Project Close Meeting	Meeting	M0 + 36M

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

Mandatory skills:

- Applicant(s) will need to have an in-sight knowledge in multi-scale modelling in the industrial sectors
- Applicant(s) will have to demonstrate experience of multi-scale analysis using adaptive meshing into a commercial finite element code
- Applicant(s) will have to demonstrate contributions to this field of research at academic level
- Applicant(s) will need to be specialist(s) in advanced structural anaysis with special interest in metallic and composite failure modelling.
- Applicant(s) will have to demonstrate experience with Uncertainty Quantification and Management methods (e.g Monte Carlo, Latin Hypercube, Mean Value Method, 1st and 2nd order Reliability Methods, etc)
- Applicant(s) should be familiar with aircraft design

Mandatory equipment:

- Applicant(s) will need to have access to the commercial software Abaqus in order ensure due course of this project; a direct relationship with software provider, is preferred
- Sufficient Abaqus licences to run large model (100 licences)
- Applicant(s) should have access to a statistics & design of experiment software, such as OpenTurns or JMP.
- High Performance Computing ressource to ensure that large model (>3million elements) can be investigated

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

XIII. Active Cockpit Simulator & Ground Station Facility Test Environment Enhancement

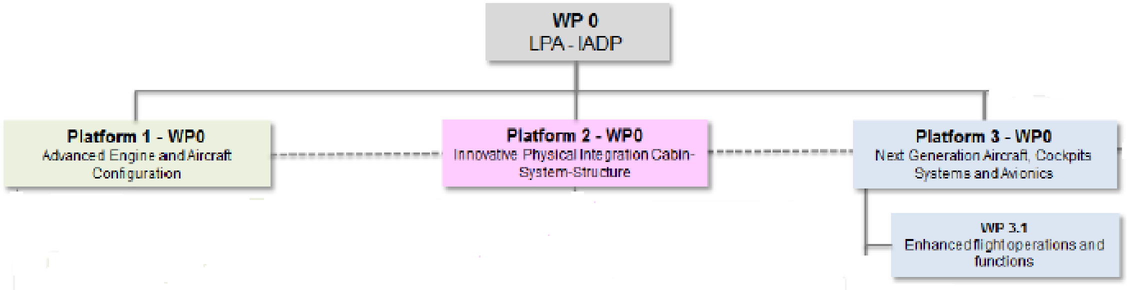
Type of action (RIA or IA)	IA		
Programme Area	LPA, Platform 3, WP 3.1		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	1 500 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	20 months	**Indicative Start Date**[14]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-LPA-03-08	**Active Cockpit Simulator & Ground Station Facility Test Environment Enhancement**
Short description (3 lines)	
The objective is to develop HW & SW to enhance the current Active Cockpit Simulator integrating an advanced Ground Station Console configuration for a new Regional Aircraft Concept of Operation. It will allow performing the Human Factor Validation of CS2 LPA PT3 Reduced Cockpit Workload Technologies in a new generation Test Environment.	

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

1. Background

In the framework of the Clean Sky 2 LPA PT3 several technologies for pilot workload reduction are being developed by Airbus Defence and Space in WP3.1 (Enhanced Light Weight Eye Visor, Cockpit Automated Procedures System, Voice Command, Pilot Monitoring System and Aircraft Monitoring Chain for Ground Support System).



These technologies demand an innovative cockpit test environment to enable a truly quantitative Human Factors Evaluation for a new Regional A/C concept of operation.

In particular the objective of this topic is about the integration of new functionalities onto the current Regional Active Cockpit Simulator located in Airbus Defence and Space facilities..

The departing test facility aims at developing a new avionics suite for regional A/C. to allow .Operational test pilots in early stages of the development. The Clean Sly2 LPA PT3 roadmap will build on these results to perform the Human Factors Evaluations.

At present the test facility provides a flexible cockpit layout reconfigurable to different representative twin pilot cockpits using:

- multitouch displays for interaction and virtual representation,
- a sound system for generic environment sounds and alarms
- a single visual system projector..

The applicant is expected to propose and develop an innovative architectural solutions The test facility must offer the research capabilities to integrate a set of technologies that will enable quantitative measurements in a single cycle during the human factors demonstration for a highly represenative regional A/C simulation.

The outputs of the project will be exploited for Avionics research and innovation activities in Airbus Defence and Space facilities along Clean Sky 2 program and potentially beyond.

2. Scope of work

Tasks		
Ref. No.	***Title – Description***	***Due Date***
WP1	Development of Out of the Window day / night test environment (150x40 degrees visual system, lighting system representing sun light, frame enclosure for night low light evaluation scenes.)	**T0+20**
WP2	Development of Enhanced instrument panels and flight controls representation	**T0+20**
WP3	Development of a beyond state of the art pilot and copilot monitor sensors system	**T0+20**
WP4	Development of an innovative 3D sound Environment	**T0+20**
WP5	Develop, design and manufacture of Ground Station Console Simulator Facility including Data Link simulation models	**T0+20**

The key innovation aspects are highlighted here below;

WP 1 Development of Out of the Window day / night test environment

The single illumination room concept envisages multiple external ambient light conditions (day/sunset/night including through the window effects) and highly representative transitions phases in an integrated simulation cycle providing full coverage of the out of the window scene (150x40 degrees). This is a key aspect to verify & validate the Light Weight Pilot Eye Visor technologies close to operational conditions.

A removable shell representative of a twin cockpit for a regional A/C and a dark room frame solution will be required.

The lighting system must emulates the parallel light of the sun with a coverage of 180x90 degrees. The ilumination system shall provide either a continuous angle selection for azimut and heading or stepper angle selection from with in the defined coverage. A remote control to automatically position the direction of the light and the ilumination intensity need to be included.

WP2 Development of Enhanced instrument panels and flight controls representation

A solution exploring a continuous multitouch and display surface with contour adjusted for each of the instrument panel covering the complete surface of the front panel should be proposed.

The enhancement of the instrument panels representation will consist of a single monitor development equivalent to two 46” 4K multitouch monitors side by side. For the pedestal and the overhead the monitors could be i-between 40” and 42” 4K monitors. Those continuous high resolution surfaces need to be also multitouch and with a multitouch resolution capable to manipulate a virtual switch with a 5 mm size. This innovative instrument panel is not currently available in the market and specific HW and SW developments are required to design and build the multitouch surfaces for a cockpit application.

For regional flight controls a set of column, yoke and a set of pedals representative in size, displacements and forces of a regional A/C flight controls. The size is important to provide the right ergonomy to the pilot or copilot and to check the impact of the other elements under test in the capability of the pilot to fly the aircraft. When the remote control starts playing its roll, the colums and yoke needs to be actually moved to effectively take control of the aircraft.

WP3 Development of a beyond state of the art pilot and copilot monitor sensors system

Airbus Defence and Space is willing to integrate sensors to catch up the expressions of the pilot or physical variables. The applicant is invited to explore data decluttering capabilities for measured parameters to provide the levers for procedure automation and to check the Pilot Monitoring System.
Solutions including the following sensors should be explored in the frame of the project: biometric sensors including galvanic skin response, heart parameter sensors, mental stress monitoring sensors and wireless interfaces.
Solutions including the following recognition technologies should be explored in the frame of the project: cameras & SW for recognition and face expression analysis, eye tracker with pupil diameter recognition, eye blinking rate sensor for both pilot and copilot and cortisol detector.
Other systems configurations can be proposed by the applicant for down selection of technologies.

For stress enforcement an electrostimulation system shall be explored for both pilot and copilot.

For wireless interfaces a wireless jammer shall be provided in the bands Zigbee/Bluetooth/Wifi (433Mhz/868Mhz/915Mhz/2,4Ghz). Two more alternative wireless interfaces shall be proposed for investigation purposes and comparison with current available: the new LiFi that uses pulse IR light and the WAIC which is the new proposed aeronautics Wifi.

The solutions must be non intrusive and non obtrusive to allow the normal operation of the pilot and must be independent of the sensors included in the Pilot Monitoring system.

WP4 Development of an innovative 3D sound Environment

The technology available in the market for 3D Cockpit sound environment is not representative of a regional aircraft. We expect a noise test environment enough close to reality to allow measurements for the analysis of the voice command system interaction with the pilot voice. In particular the applicant is invited to explore the identification, separation and generation of the basic sound samples. It will require the conceptualization and development of a sound model able to process the samples together with the parameters driving the phenomenon to generate a 3D sound environment. The applicant model will be validated with original sound environment.

WP5 Develop, design and manufacture of Ground Station Console Simulator Facility including Data Link simulation models

The console simulator displays will reproduce the pilot view inside the cockpit and also a view of the situation of the aircraft. The console has to provide a new concept of controls (i.e.: touchscreen,…) and displays (i.e.: 3D sterocopy vision, virtual reality….) to override the pilot actions and let the ground station operator to pilot the regional aircraft safely to ground.

3. Major deliverables/ Milestones and schedule (estimate)

		Deliverables		
	nº	***Title – Description***	***Type***	***Due Date***
WP1	D1.1	Preliminary Out of the window overall design integrated with active cockpit	(D) Document	T0 + 3
	D1.2	Out of the window overall design integrated with active cockpit	(D)Document	T0 + 6
	D1.3	Readiness review for active cockpit enclosure, visual system and lighting system	(R&D) Demonstration Document + Drawings	T0 + 10
	D1.4	Enclosure delivered and integrated with active cockpit	(HW) Delivery + partial acceptance	T0 + 12
	D1.5	Visual system delivered and integrated with active cockpit	(HW) Delivery + Partial Acceptance	T0 + 14
	D1.6	Lighting system delivered and integrated	(HW) Delivery + Partial Acceptance	T0 + 16
	D1.7	Fine tuning for cockpit enclosure, visual system and lighting system	(R) Acceptance Document	T0 + 18
WP2	D2.1	Preliminary Cockpit shell, instruments panel and flight controls design	(D) Document	T0 + 3
	D2.2	Cockpit shell, instruments panel and flight controls design	(D) Document	T0 + 6
	D2.3	Readiness review for Cockpit shell, instruments panel and flight controls	(R) Demonstration Document + Drawings	T0 + 10
	D2.4	Cockpit removable shell delivery and integration	(HW) Delivery + Partial Acceptance	T0 + 12
	D2.5	Instrument panels delivery and integration	(HW) Delivery + Partial Acceptance	T0 + 14
	D2.6	Flight controls delivery and integration	(HW) Delivery + Partial Acceptance	T0 + 16
	D2.7	Fine tuning for Cockpit shell, Instrument panels and flight controls	(R)Acceptance Document	T0 + 18
WP3	D3.1	Preliminary active cockpit sensors integration design	(D) Document	T0 + 3
	D3.2	Active cockpit sensors integration design	(D)Document	T0 + 6
	D3.3	Active cockpit sensors integration readiness review	(R) Demonstration Document + Drawings	T0 + 10
	D3.4	Biometric sensors integrated in active cockpit	(HW) Delivery + Partial Acceptance	T0 + 12
	D3.5	Mental stress sensors integrated with active cockpit	(HW) Delivery + Partial Acceptance	T0 + 14
	D3.6	Wireless interfaces integration	(HW) Delivery + Partial Acceptance	T0 + 16
	D3.7	Fine tuning Active cockpit sensors	(R) Acceptance Document	T0 +18
WP4	D4.1	Preliminary 3D Sound system design review	(R) Document	T0 + 3
	D4.2	3D Sound system design	(D) Demonstration + Document + Drawings	T0 + 6
	D4.3	Sound 3D environment acquisition system and field sound recording	(HW) Delivery + SW sound Files	T0 + 8

		Deliverables		
	nº	***Title – Description***	***Type***	***Due Date***
	D4.4	Sound 3D processing tool delivery	(HW) Delivery + Partial Acceptance	T0 + 10
	D4.5	3D Sound laud speaker system integrated with active cockpit	(HW) Delivery + Partial Acceptance	T0 + 12
	D4.6	3D Sound model integrated with active cockpit	(HW) Delivery + Partial Acceptance	T0 + 14
	D4.7	Sound model validation against field recording	(HW) Delivery + Partial Acceptance	T0+16
	D4.8	Fine tuning 3D environmental Sound system	(R) Acceptance Document	T0+ 18
WP5	D5.1	Ground Station Lay out definition	(D) Document	T0 + 3
	D5.2	Ground station design	(D) Document	T0 + 6
	D5.3	Ground station readiness review	(R) Demonstration Document + Drawings	T0 + 10
	D5.4	Ground station HW delivery and integration with active cockpit	(HW) Delivery + Partial Acceptance	T0 + 12
	D5.5	Ground station SW models and datalink integrated with active cockpit	(D)Document	T0 + 16
	D5.6	Ground Station fine tuning	(D) Document	T0 + 18

Milestones		
Ref. No.	***Title - Description***	***Due Date***
M0	KOM: Kick of meeting	T0
M1	PDR: Suplier provides a preliminary design agreed with Call requester	T0+3
M2	CDR: Suplier provides a detailed design agreed with Call requester and freezed	T0+6
M3	Preliminary Acceptance of the solutions provided prior to deliver to Active Cockpit	T0+10
M4	Integration of the solutions in the Active cockpit	T0+16
M5	Test dry run and fine tuning of the solutions to reach a satisfactory solution performance	T0+18
M6	Solutions integrated ready for new technologies evaluations with pilot in the loop	T0+20

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

Experience in development of aeronautical simulators systems, both HW and SW

- Experience in aeronautical interfaces (ARINC429, ARINC629, MIL-STD-1553, AFDX)
- Experience in ARINC 653 / Integrated Modular Avionics
- Experience in wireless technology within the aeronautical domain
- Experience in Test Rig environments including Signal Stimulation and Acquisition System (SEAS).
- Capacity to provide support to system functional tests of simulators:
- ISO 9100 certification
- Experience in development of simulators visual systems
- Experience in remote controlled Illumination systems
- Experience in development of Aircraft Simulators Cockpits
- Experience in development of LED displays and wall mounted displays

- Experience in simulator flight controls
- Experience in development and integration of biometric sensors applications
- Experience in development and integration of mental stress generation systems
- Experience in development and integration of wireless interfaces.
- Experience in development of 3D sound systems
- Experience in audio processing.
- Experience in audio recording systems.
- Experience in development of aircraft or consoles simulators
- Experience in GUI and HMI interfaces for simulation

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

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, WP 2.1 Adaptive Electric Wing		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	1200 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	18 months	**Indicative Start Date**[15]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-REG-01-05	**Green Turboprop configuration - Natural Laminar Flow adaptive wing concept aerodynamic experimental validation (WTT2)**
Short description (3 lines)	
Low Speed Experimental Investigation of a Large scale complete aircraft model integrating different High lift morphing devices. Activities include modifications of an existing large scale A/C model (scale 1:7) to include new morphing high lift device shapes (droop nose, fowler flaps) and to validate the relevant aerodynamic performances at A/C level.	

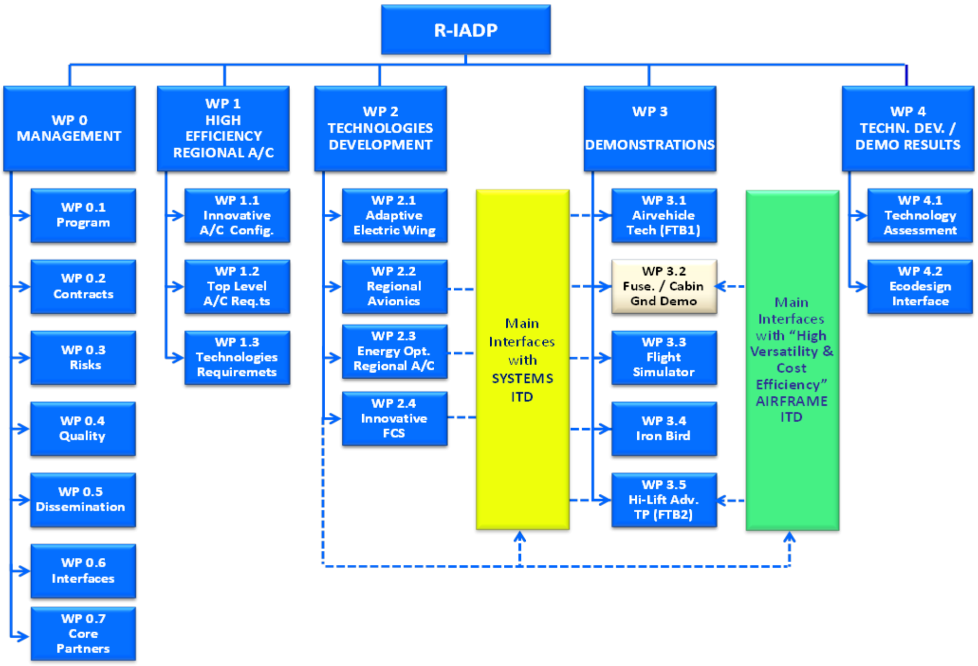
[15] The start date corresponds to actual start date with all legal documents in place.

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 (Finmeccanica Aircraft Division) will mainly focus on the demonstration of technologies improving the cruise and climb performance, while FTB#2 (Airbus Defense and Space) 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, flight simulator and iron bird.

The Regional Aircraft -IADP WBS is below reported



Focusing the attention activities planned in WP2.1, Innovative active High lift 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.
- 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 HLD morphing concepts will be validated through large scale wind tunnel experimental testing on a scaled complete powered A/C model integrating advanced morphing configuration (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, an existing 1:7 scaled complete A/C powered wind tunnel model will be modified to achieve an improved turboprop green configuration as well as to ingrate innovative HLD morphing devices. As second step of the activities low speed wind tunnel tests will be performed to validate A/C performances in take-off, landing and approaching conditions. Activities can be organized in the following Tasks:

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 1.1	Management	M18
Task 2.1	WT Model modification- Mechanical Design	M09
Task 2.2	WT Model Instrumentation	M09
Task 2.3	WT Model - Manufacturing and Assembling	M15
Task 3.1	WT testing	M16
Task 3.2	Data analysis and Report	M18

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 ITD core partners and the present project, the present task will assure suitable communication between consortium, topic manager (ITD leader) and JU.

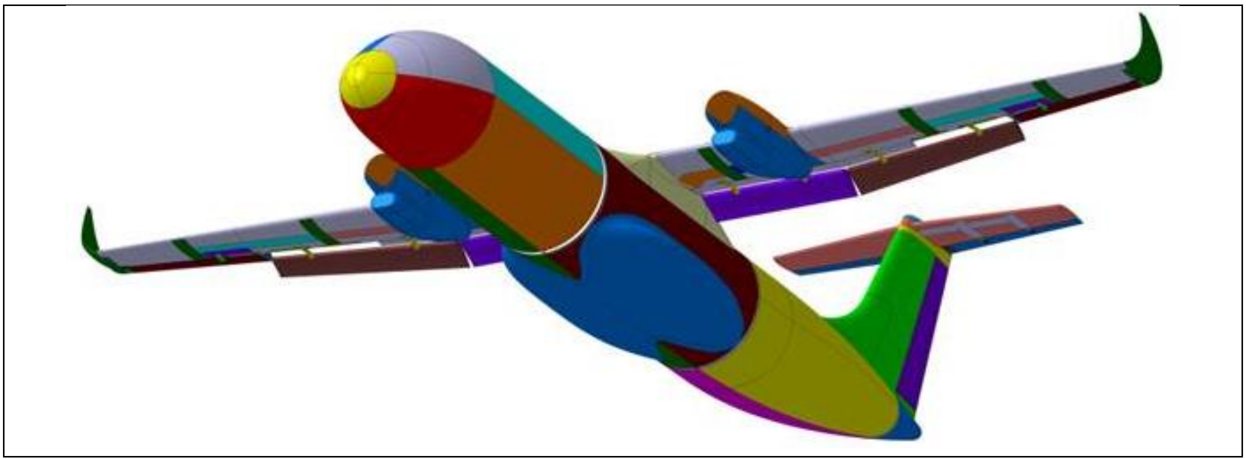
Task 2.1: WT Model modification- Mechanical Design

An existing large scale (1:7) complete powered wind tunnel model representative of the green turboprop configuration has been designed and manufactured within a previous Clean Sky call for proposal (Grant Agreement n° 620108– LOSITA project). The model will be finally aerodynamically and acoustically tested in the LLF –RUAG wind tunnel in first half of 2016.

In detail, the model has been designed with a modularity philosophy to allow different testing capabilities in terms of High lift configurations. The model is equipped with powered rotor blade engines supplied by a oil pressurized oil system. Engine units have been designed to simulate desired thrust coefficients during wind tunnel tests. Thrust forces generated by engine simulator during tests will be detected by a Rotating Balance System (RBS) installed on the blade shaft.

Within the present task, based on inputs (TP A/C geometry, High Lift devices, technical specification for WT testing) the existing model has to be modified to achieve the new TP green A/C configuration. Modifications are mainly expected on the following A/C sub-components:

- Front – Central Fuselage: Modifications are related the overall A/C fuselage length, the wing body fairing and the fuselage Main Landing gear region.
- Tail Plane – Modifications are mainly related to the fuselage-tail plane interface
- Wings – Modifications are related to the whole wing to allow the installation of innovative morphing HLD devices (Trailing Edge(TE), Leading Edge (LE) and wing tip devices). Removable wing components will allow testing clean and morphing shape configurations (no morphing actuations is foreseen). Further, modifications are expected to the engine nacelle-wing interfaces.
- Engine nacelle- Modifications are related to the new engine nacelles shape.



While the existing model has been designed to be tested in RUAG LLF wind tunnel, other large facilities could be proposed by the applicant. In the latter case, the design of dedicated wind tunnel-model interfaces are part of the present task and complete new model propulsion systems (electrical, air, oil, etc depending on the selected wind tunnel facility) have to be designed , realized and tested:

- To fit the engine nacelle external shape, as resulting from input CATIA surfaces;
- To match propeller thrust - according to input data.

The capability to set and keep thrust developed by each of the Engine Simulators within 5% of the target value is required. Expected requirements for the engine power units are:

  - Engine power > 50 Kw
  - Trust > 450 N
  - Torque Moment > 80 Nm
  - Rpm > 6000 rpm

Design activities have to be supported by suitable stress analysis to verify the compliance with Wind tunnel safety needs as well as to estimate the impact of modifications on the static and dynamic behaviour of the overall model (static model deformation under wind tunnel loads and natural frequencies).

Task 2.2: WT Model Instrumentation

This task is responsible for the wind tunnel/model instrumentation definition. In detail, the model will be equipped with about 200 steady pressure taps and 10-15 unsteady pressure sensors (such as Kulites) for local steady and unsteady pressure measurements. The Applicant shall propose a suitable way to integrate instrumentation with minimal flow disturbance.

In order to detect global aerodynamic loads acting on the complete A/C model, a suitable six components balance system shall be integrated in the A/C model sting while a Rotating balance system (or other equivalent systems) will allow gathering Trust loads generated by engine unit during tests. At least two 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 Assembly

This task is responsible for the manufacturing of the designed sub-components to achieve the TP green A/C configuration. The challenge in the final assembly will be to provide a complete full model respecting challenging requirements in terms of step. In this regard, 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 articles the following tolerances are required:

Parameter	Required Accuracy
Geometrical deviation (lengths)	0.5%
shape deviation (difference between real and design shape)	wing ± 0.2 mm(x/c<=0.5) ± 0.4 mm (x/c>0.5) Other A/C components ± 0.5mm
Surface gap (gap between different assembled parts)	Wing ≤ 0.2 mm (x/c<=0.5) ≤ 0.3 mm (x/c>0.5) Other A/C components ≤ 0.4 mm(x/c>0.5)
Upstream step (step between different assembled parts)	Wing ≤0.2 mm Other A/C components ≤0.3 mm
Downstream step (step between different assembled parts)	Wing ≤0.1 mm Other A/C components ≤ 0.2 mm
Smooth surface roughness	Wing <0.8 µm (x/c<0.4) <1.6 µm (x/c>0.4) Other A/C components <1.6 µm
Pressure Taps diameter	<0.5mm
Movable surface deflection angle	± 0.25°

Task 3.1: Wind tunnel Testing

The wind tunnel test campaign shall be performed in a wind tunnel facility large enough to install 5-6m A/C model. Tests are planned at low speed regime (Mach range ≈ 0.2 - 0.3) and high Reynolds numbers in order to validate in a representative environment Active High lift systems.

The concerned tests will be split into following phases:

1. Phase #1 – High Lift Conditions: This phase is aimed to validate at take-off and approach conditions the whole A/C configuration in terms of high-lift design performance. Tests in the Mach range between 0.2 and 0.3 on the clean and HLD A/C configurations are planned to validate the effectiveness of Morphed LE and TE devices in High Lift conditions.
2. Phase #2 – High Lift Conditions: This phase is aimed to experimentally detect optimal HLD configurations in terms of LE and TE devices (deflection angle, flap distance, etc).

During tests, the following measurements are envisaged:

- Steady and unsteady pressure measurements;
- Aerodynamic forces balance measurements to gather lift, drag, pitching moment and roll (bending) moment;
- Engine Thrust parameters

Task 3.2: Wind tunnel data

This task is responsible for the critical analysis of wind tunnel data to achieve the aerodynamic database of the green turboprop A/C. Effectiveness of LE-HLD and wind tip morphing surface in A/C take-off and landing configuration will be analysed. Experimental data analysis shall be supported by relevant CFD simulations, in charge to the applicant, to estimate Reynolds number and scaling effects referred to full scale conditions.

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	M18
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	M06
Del 2.2	Model Critical Design Report: The design of the TP green complete scaled powered A/C integrating HLD morphing systems is performed supported by extensive stress verifications	R, D	M09
Del 2.3	Model Manufacturing 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.	R	M15
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	M15
Del 3.3	WT test Outcome: Based on the carried-out experimental and numerical data performed by Applicant:Test data are fully described and HLD and morphing devices relevant aerodynamic data base is created supported by CFD simulations. Wind Tunnel test corrections procedures are described;	R, D	M17

Del 3.4	A/C High Lift performances: this report will provide a detailed analysis of wing performances in regard to the different tested technologies.	R,	M18

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Model Design: Modification to the existing TP green A/C model have been designed to integrate HLD technologies	R	M09
M2	Model ready: The design of the TP green complete scaled powered A/C integrating HLD morphing systems is performed.	R	M15
M3	Green Turboprop aerodynamic database: The experimental aerodynamic database concerning HLD and morphing shapes, is available._	R	M18

(*R=Report; D=Data, drawing)

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

- Expertise in CATIA V5 software for aeronautical applications.
- Consolidated experience in designing and manufacturing of large wind tunnel models.
- Consolidated experience in design of powered engine simulator for wind tunnel model.
- Large experience in Wind tunnel test activities and data analysis.
- General aerodynamic CFD modelling and simulations.

II. High Fidelity Integrated Non-Linear MBS Modelling of Morphing Wing

Type of action (RIA or IA)	IA		
Programme Area	REG, WP 2.1.2 – Morphing Structures		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	350 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	18 months	**Indicative Start Date**[16]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-REG-01-06	**High Fidelity Integrated Non-Linear MBS Modelling of Morphing Wing**
Short description (3 lines)	
Investigation of efficient modelling methods for high fidelity numerical simulation models based on non-linear multi-body mechanical structural models (MBS) for the qualification of morphing devices and validation with a wing model integrated a winglet, Fowler flap, wing tip & droop nose.	

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

1. Background

Investigation of efficient modelling methods for high fidelity numerical simulations, based on non-linear multi-body mechanical structural models. These will modelling methods will be used to carry out the qualification of morphing devices (Winglet, Morphing Fowler, Wing Tip & Morphing droop nose) that have been designed by the Core partners already included in the REG-consoritium in order to define the most significant enveloping operational load conditions in preparation of the ground structural mechanical tests. After ground tests these models shall be updated and used for the finalization of loads prediction and flight clearances for FTB#1 demonstrations. The modeling methods shall be capable to rationally condensate the aerodynamic pressures pertinent to load conditions into an equivalent set of distributed forces. Structural stiffnes, damping and lumped masses shall be modeled coherently with the structural design FEM models of morphing elements. The modelling methods will include the actuators static and dynamic modelling and will enable the recovery of the target morphed shape under applied loads. Methods to model displacements sensors for the devices shape reconstruction during tests shall be considered in order to estimate the values of displacements expected to be measured by all sensors during experimentation, both on ground and in flight. Method to predict mechanical failures dynamic conditions shall be included so to verify the safety assessment requirements.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
1	Investigation of non-linear multi-body modelling methods for morphing mechanisms	M3&M18
2	Global 3D FEM-MBS integration model architecture	M2
3	Droop nose MBS model	M9
4	Trailing Edge Flap MBS model	M9
5	Winglet MBS model	M9
6	Wing Tip MBS model	M9
7	Composite Wing Box model	M12
8	Integration of the mechanism models and the wing box model	M15
9	Integrated model verification and validations	M18

1. Investigation of non-linear multi-body modelling methods for morphing mechanisms

To advance the State-of-the-Art of the simulation methodology, this task will investigate optimal modelling methods for morphing mechanisms that are used for load control and alleviation and high lift purposes. The modelling methods will be based on non-linear multi-body simulation and will be demonstrated using software of Siemens PLM Software. Some of the main challenges that are anticipated will be modelling of sensors, modelling of the non-linear flexible components, modelling of aerodynamic loads, modelling of actuators and controllers and tuning of the solver for optimal performance.

This task will run over the full duration of the project with a first version of the deliverable expected at M3 and then an updated version at the end of the project. The outcome of this task will be validated during the subsequent tasks where the identified methods will used to model the required mechanisms and the integrated wing.

Input:	***Output***:
- Review of state-of-art of modelling method for multi-body simulation and modelling of compliant structures	D1: Synthesis report of best modelling methods and modelling guidelines

2. Global 3D FEM-MBS integration model architecture

In this task, the Partner will prepare the specifications of global 3D FEM-MBS integration model architecture based on the requirements of the TM. The configuration and parameterization requirements as well as the requirements for sensors and simulation outputs will also be considered.

Input:	***Output***:
TM specifications and general requirements - Configuration and parameterization requirement - Output and sensor requirements	D2: Specifications of the global 3D MBS modeling integration environment architecture

3. Droop nose MBS model

This task addresses the preparation of the droop nose MBS model. The MBS model will be based on the design results from the activities by the core partners. Therefore, the partner will be provided the final design and related data needed to prepare a MBS model of the Morphing Leading Edge. Due to the large deformation of the skin, it will be modelled non-linearly. Static and dynamic actuation models as well as simplified local control logic needs to be included.

Input:	***Output***:
- LE: Technical documentation of the morphing flap design - LE: Technical documentation of the actuators and local controller - LE: Aerodynamic pressures maps and forces corresponding to stationary loading - LE: Digital mock-up (3D CAD)	D3: NL-MBS model of Droop nose with documentation

4. Trailing Edge Flap MBS model

This task addresses the preparation of the Trailing Edge flap MBS model. The MBS model will be based on the design results from the activities by the core partners. Therefore, the partner will be provided the final design and related data needed to prepare a MBS model of the Trailing Edge. The model will integrate the morphing flap and this deployment system. The model will include an appropriate representation of the segmented skin that will be used in the design of the trailing edge flap. Static and dynamic actuation models as well as simplified local control logic needs to be included.

Input:	***Output***:
- TE-FLAP: Technical documentation of the morphing flap design - TE-FLAP: Technical documentation of the deployment system - TE-FLAP: Technical documentation of the actuators and local controller - TE-FLAP: digital mock-up (3D CAD)	D4: MBS model of the TE-Flap with deployment system with documentation

5. <u>Winglet MBS model</u>

This task addresses the preparation of the Winglet MBS model. The MBS model will be based on the design results from the activities by the core partners. Therefore, the partner will be provided the final design and related data needed to prepare a MBS model of the Winglet. Due to the large deformation of the skin, it will need to be modelled non-linearly. Static and dynamic actuation models as well as simplified local control logic needs to be included.

Input:	***Output***:
- Winglet: Technical documentation of the morphing flap - Winglet: Technical documentation of the actuators and local controller - Winglet: digital mock-up (3D CAD)	D5: Winglet MBS model with documentation

6. <u>Wing Tip MBS model</u>

This task addresses the preparation of the Wing Tip MBS model. The MBS model will be based on the design results from the activities by the core partners. Therefore, the partner will be provided the final design and related data needed to prepare a MBS model of the Wing Tip. As this is not a compliant mechanism, only linear flexibility will be considered. Static and dynamic actuation models as well as simplified local control logic needs to be included.

Input:	***Output***:
- Wingtip: Technical documentation of the morphing flap concept - Wingtip: Technical documentation of the actuators and local controller - Wingtip: digital mock-up (3D CAD)	D6: Wing Tip MBS model with documentation

7. <u>Composite Wing Box model</u>

This task addresses the preparation of the Composite Wing Box to be included in the integrated MBS model. The partner will be provided the final design and related data needed to prepare a Wing Box model, this will include the composite material properties and ply layup.

Input:	***Output***:
- Wing Box: Technical documentation of the Composite Wing Box	D7: Updated Composite Wing Box model with documentation

8. <u>Integration of the mechanism models and the wing box model</u>

This task addresses the integration of all the mechanisms with the wing box in one high fidelity NL-MBS model. Sensors need to be included that measure the required outputs. Aerodynamic loads will be applied on the wing box and aerodynamic surface of the mechanisms.

Input:	***Output***:
- All previous deliverables - Aerodynamic pressures maps and forces corresponding to stationary loading	D8: Integrated MBS model of updated Composite Wing Box model assembled with the mechanisms and compliant structures, including actuators, local control logic and aeroloads

9. <u>Model verification and validations</u>

Improvement and tuning of integrated MBS model of the integrated wing with simulation runs that verify that the simulation models produces meaningful results for all required load cases and validate the results with respect to results obtained during the design phase of the wing structure and the mechanisms.

Input:	***Output***:
- D7 - Test cases and validation data	D9: An optimized integrated MBS model of the integrated wing and simulation results together with documentation and user guidelines

3. <u>Major deliverables/ Milestones and schedule (estimate)</u>

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	Synthesis report of best modelling methods and modelling guidelines	R	M3
D2	Specifications of the global 3D MBS modelling integration environment architecture	R	M2
D3	NL-MBS model of Droop nose with documentation	M, R	M9
D4	MBS model of the TE-Flap with deployment system with documentation	M, R	M9
D5	Winglet MBS model with documentation	M, R	M9

D6	Wing Tip MBS model with documentation	M, R	M9
D7	Updated Composite Wing Box model with documentation	M, R	M12
D8	Integrated MBS model of updated Composite Wing Box model assembled with the mechanisms and compliant structures, including actuators, local control logic and aeroloads	M	M15
D9	An optimized integrated MBS model of the integrated wing and simulation results together with documentation and user guidelines	M, R	M18

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
MS1	Multi-body models of Morphing Devices – Acceptance of D1, D2, D3, D4, D5	R	M9
MS2	Morphing Devices Model integrated in wing box and model Validated – Acceptance of D6, D7, D8	R	M18

(*R=Report; M=simulation model)

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

- Extensive experience in creating complex multi-body simulation models, preferable using SIEMENS PLM software
- Experience with modelling of compliant structures
- Experience with aircraft design in general and design of high lift and load control and alleviation devices in particular
- All MBS models have to be based on the multi-body simulation software of SIEMENS PLM in order to be compatible with the TM simulation environment. Free software licenses and training for the relevant SIEMENS PLM software can be provided for the duration and scope of the project.

III. Innovative alloy development for structural part fabrication with Additive Manufacturing Technology

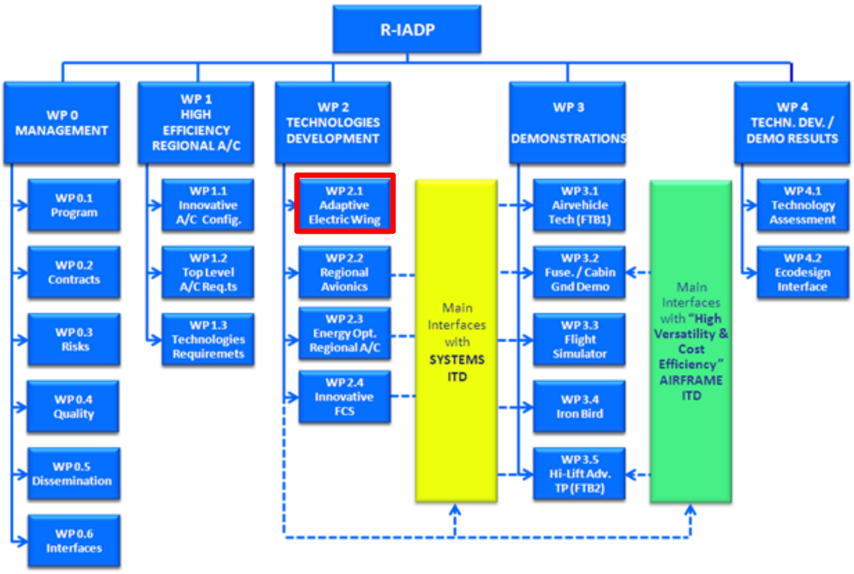
Type of action (RIA or IA)	IA		
Programme Area	REG, WP 2.1 [Adaptive electric wing]		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	600 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	36 months	**Indicative Start Date**[17]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-REG-01-07	**Innovative alloy development for structural part fabrication with Additive Manufacturing Technology**
Short description (3 lines)	
Activities described in the present Topic shall contribute to develop, by powder technology and Additive Manufacturing process, a new aluminum alloy with performances similar to structural alloys (7000 series). With this new alloy it will be possible to produce, by Additive Manufacturing process, accurate structural parts currently produced by traditional processes. Then the Additive Manufacturing process may allow to reduce the costs and the lead time of production and to reduce significantly the weight of the parts.	

[17] 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 2.1 "Adaptive electric wing" 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 2.1:



More in detail, the activities will pursue the development of a new aluminum alloy that can be produced by powder metallurgy technique and can be used in the Additive Manufacturing (AM) process to produce aeronautical structures. Currently the AM machine manufacturers supply several materials (with the related deposition process) that include an Al Alloy (AlSi10Mg) having performances not suitable for structural parts.

The objective is to drive the development of a new material and Additive manufacturing process to obtain increased structural integration, reduced total costs and structural weight, reduced environmental impact.

2. Scope of work

The scope of the present Topic is the development of a new high performance aluminium alloy feasible by powder metallurgy and the development of the additive manufacturing process to obtain the requested characteristics in terms of mechanical strength and corrosion resistance.

The following table shows some of the requested characteristics.

Ftu [KSI]	L	69
	LT	70
Fty [KSI]	L	55
	LT	60
Fcy [KSI]	L	55
	LT	60
Fsu [KSI]		41
FBRU	e/D=2	105
	e/D=1.5	130
e %		5
E [10^3 KSI]		10
Ec [10^3 KSI]		10
G [10^3 KSI]		3.9

A mechanical characterization of the new material is deemed necessary for component structural validation.

Main requirements of the innovative aluminium alloy are:

1) Feasibility by powder metallurgy technics
2) Weldability
3) Suitable for Additive manufacturing process
4) Tensile strength/elongation comparable with traditional technologies
5) Corrosion resistance
6) Inspectionability with NDI consolidated technique

To achieve the proposed objectives, the main activities to be performed are:

- Definition innovative alloys feasible by powder technology.
- New powders manufacturing.
- Deposition tests in order to identify and select the alloy that have the best performances after deposition by Additive Manufacturing process. For each alloy the best set of AM parameter will be defined and used for the tests.
- Definition of the heat treatment cycle that gives the best performances of the selected alloy.
- Characterization of the new alloy obtained by powder technology and Additive Manufacturing process. The characterization tests will be done with and without heat treatment in order to define

if it’s possible to avoid the heat treatment after the deposition process.

- Demo part design / manufacturing and verification

The activities are divided in the tasks listed in the following table:

Tasks		
Ref. No.	***Title – Description***	***Due Date***
1	Definition of innovative alloys feasible by powder technology	T0 + 6 months
2	New powders manufacturing	T0 + 18
3	Deposition test and powder selection	T0 + 27
4	Heat treatment cycle optimisation	T0 + 30
5	New alloy characterization before and after heat treatment, with and without surface machining	T0 + 33
6	Demo part manufacturing and verification	T0 + 36

The following inputs shall be provided by the Topic Manager:

- Allowable test plan
- 3D models of demonstrator
- Physical and mechanical characteristic

Topic Manager will define the main specification of the new alloy in terms of mechanical, metallurgical and chemical characteristics.

Task 1 - Definition of innovative alloys feasible by powder technology

Actually the aluminium alloy available for the additive manufacturing process is the AlSi10Mg, that is not suitable for structural applications.

The new material will be utilized for the manufacturing of structural parts, then it must have better performances that will be identified.

With the contribution of powders manufacturers, shall be defined the chemical composition of new alloys that potentially meet the specifications required and are suitable for the Additive manufacturing process.

The powders for additive manufacturing process must be characterized by a spherical morphology and high packing density, which confer good flow properties.

For powder bed processes these are essential when applying fresh powder layers to the bed to ensure uniform and consistent part build.

For blown powder processes good flow ensures uniform build rates. Tight control of the particle size distribution also help ensure good flowability.

Task 2 - New powders manufacturing

The powders of the new alloys will be produced and will be assessed which are suitable for Additive Manufacturing process.

The chemical composition must be strictly controlled.
Out of the alloys identified in the previous task two or three alloys will be selected for further investigation

Task 3 – Deposition test and powder selection
In this task shall be assessed which powder is the most suitable for the additive manufacturing process, in terms of defects as cracks and porous present in the deposed metal. Deposition test with all powders produced shall be done. For each alloy it's necessary a process development to define the best AM parameters.
A certain number of specimens, for each one of the tested alloys, will be produced and will be subjected to the following analysis:
- NDI for internal and external defect.
- Chemical composition
- Metallurgical analysis for microstructure evaluation

The most performing alloy will be selected for the next tasks.

Task 4 – Heat treatment cycle optimisation
In order to improve the mechanical performances end corrosion resistance of the new alloy, a certain number of test will be done to define the best thermal treatment optimized according to the following steps:

- Study of thermal cycle more suitable for the new alloy, taking in account the initial condition of the material and the expected improvement of the mechanical/ physical characteristics
- Thermal treatments of representative coupons
- Testing to validate the best thermal treatment
- Best thermal treatment selection

Task 5 – New alloy characterization before and after heat treatment, with and without surface machining
A characterization campaign will be performed on ASTM standard specimens, for the new selected material in conditions before and after thermal treatment.
The surface roughness could have an influence on mechanical performances of the deposed material.
In order to evaluate the influence of the surface roughness on mechanical performances of the deposed material, the most representative tests shall be done on specimens with the surface as deposed and on specimens where the surface is mechanically removed.

The following test will be performed:
- Static
- Fatigue
- Metallographic
- Chemical
- Galvanic compatibility

In order to optimize the testing results, the specimens, before mechanical test, will be subjected to NDI to evaluate possible failures.

Task 6 – Demo part manufacturing and verification
Topic Manager will develop the design methodologies in order to maximize the advantages of the additive manufacturing technology:

- Freedom of design
- Complex shape, inner cavities or foam / lattice structures, impossible to produce by machining
- Thin walls & shapes impossible to produce by casting
- Light weight parts with lattice / foam inner structures
- Flexibility in design changes
- Customized design
- Multiple pieces built as one
- No tool needed
- Short production time (a few hours)

Topic Manager will provide the 3D model of a demonstrator.
Two identical demonstrators will be produced by additive manufacturing process with the new aluminum alloy.
These demonstrator will be subjected to destructive and non-destructive test to be compared with the results of the characterization phase.

The following test will be performed:

- Traction
- Micrography
- NDI
- Dimensional control

3. Major deliverables/ Milestones and schedule (estimate)

	Deliverables		
Ref. No.	***Title – Description***	***Type***	***Due Date***
D1.1	Innovative Alloys feasible by Powder Metallurgy	Report	T0 + 6
D2.1	New alloys powders manufacturing	Hardware	T0 + 18
D3.1	AM process development for new alloys	Report	T0 + 21
D3.2	Specimens manufacturing	Hardware	T0 + 24
D3.3	Specimens analysis and best alloy selection	Report	T0 + 27
D4.1	Possible Thermal treatment cycles definition	Report	T0 + 28
D4.2	Thermal treatment optimization	Report	T0 + 30
D5.1	Characterization Specimens manufacturing	Hardware	T0 + 29

	Deliverables		
Ref. No.	***Title – Description***	***Type***	***Due Date***
D5.2	Characterization tests results	Report	T0 + 32
D6.1	N. 2 Demonstrator manufacturing	Hardware + Report	T0 + 34
D6.2	Demonstrator analysis	Report	T0 + 36

	Milestones (when appropriate)		
Ref. No.	***Title – Description***	***Type***	***Due Date***
M1	New alloys powders manufacturing	Hardware	T0 + 18
M2	Best powder selection	Report	T0 + 27
M3	Heat treatment optimization	Report	T0 + 30
M4	Characterization tests	Report	T0 + 33
M5	Manufacturing of Demonstrators	Hardware	T0 + 35

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

- Skill 1: proven competence in metallurgy and powder metallurgy tecniques.
- Skill 2: proven competence in manufacturing of aeronautical structural parts with additive manufacturing process.
- Skill 3: proven experience on non-destructive inspections. Evidence of NDI qualification shall be provided.
- Skill 4: proven experience in experimental testing. Evidence of laboratories qualification shall be provided.
- Skill 5: proven competence in aluminum alloys powder manufacturing.

IV. Advanced Energy Storage and Regeneration System for Enhanced Electrical Energy Management

Type of action (RIA or IA)	RIA		
Programme Area	REG, WP 2.3.4 – Advanced Electrical Power Generation & Distribution System		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	800 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	36 months	**Indicative Start Date**[18]	Q2 2017

Identification	Title
JTI-CS2-2016-CFP04-REG-01-08	**Advanced Energy Storage and Regeneration System for Enhanced Electrical Energy Management**
Short description (3 lines)	
Design, development, manufacturing, validation and integration of an innovative Energy Storage and Regeneration System (ESRS) including DC/DC bi-directional converter equipped with local supercapacitor-based energy storage elements for smart control of regenerative loads (EMAs).	

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

1. Background

In the frame of a future Regional Aircraft, the innovative Electrical Power Distribution System (EPDS) will be equipped with Enhanced Electrical Energy Management (E^2-EM) functionalities in order to first reduce or even delete the overload capabilities of main electrical generators and thus saving weight for machines integration, as well as to reduce the generators failure rate by preserving their electrical capabilities. With respect to electrical energy management concepts, as already investigated and validated within CS1 Project, the E^2-EM will also introduce utilization of local supercapacitors used as energy buffers during high and rapid transitory energy requests from some critical loads (e.g., flight control system or landing gear electro-mechanical actuators, EMAs).
This CfP mainly aims to examine the use of a supercapacitor-based energy storage device (ESD), included into a Secondary Electrical Power Distribution Centre (SEPDC) and managed by a bidirectional DC/DC converter. The SEPDC shall manage regenerative loads, such as electro-mechanical actuators, and correspondent energy management techniques to store and reuse the energy regenerated on the 270 VDC bus bar, integrant part of the SEPDC.
Currently, a number of EMAs as part of aeronautical electrical networks act as regenerative loads. EMA regenerative loads draw (during supplying phase) and reject (during braking phase) power on HVDC network. The rejected energy phenomenon time is highly variable (rejection time lies between 10ms and 5s). Currently, regeneration effects are not allowed effectively on the electrical power DC bus of the aircraft. As a common solution, the regenerative loads such as the EMAs incorporate large dissipation resistors, in order to absorb all the power rejected by the EMA without producing an overvoltage. However, these dissipation resistors add weight and volume to the equipment, having also a direct impact on the converter power.
Objective of this CfP is to propose an innovative Energy Storage and Regeneration System (ESRS) in order to avoid dissipation resistors, replacing them with supercapacitor-based systems. Moreover, the energy recovered and stored within the supercapacitors can be intelligently and effectively reused in order to smooth the power variations experienced by the generator, in EMA supplying phase (see Fig. 1a).

2. Scope of work

2.1. Objective

The scope of this CfP is to design, develop, manufacture, validate and integrate a 270V DC SEPDC embedding a supercapacitor-based ESD for the purposes of E^2-EM functionalities. A number of items shall belong to this project:

- A SEPDC, embedding a 270 VDC bus bar, with relevant contactors and protections, as well as the computational core (namely the “supervisor”) of the energy management system;
- An ESD based on supercapacitors, used as a rapid energy buffer;
- A bidirectional DC/DC converter connected to the ESD (both constituting the Energy Storage System, ESS), able to manage the power flows related to the ESD;
- A motor load simulating an Electro-Mechanical Actuator used for primary A/C surfaces or landing gear, as example of regenerative load, without dissipation resistors;

These above components shall be provided by the applicant, and together will constitute an advanced ESRS for the scopes of E^2-EM functionalities to be then integrated and tested on the primary electrical network of the Regional Iron Bird platform in order to demonstrate that relevant solutions for innovative EPDS correctly perform in a relevant operative environment (TRL 5).

The SEPDC shall exchange information with the primary electrical network using a devoted communication protocol (e.g. CAN, ARINC 429, TBD) for the aims of E^2-EM logics implementation.

The DC/DC converter equipment shall be suitable to perform advanced energy management functions by automatically reverse the operating mode, from buck to boost mode, and viceversa, as reaction to energy management objectives persecution.

2.2. Requirements

2.2.1. General Requirements

The overall system shall be fully interfaced with the Iron Bird test rig, and the energy management mode (i.e. automatic inversion of the modes) shall be activated or deactivated in case of needs depending on the specific test configuration. When activated in energy management mode, the supervisor embed into the SEPDC shall take autonomous full control of the converter, reacting to the current power absorption of the network, as well as to other parameters.

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

2.2.2. Energy Management Requirements

A key challenge of the CfP is to design the ESS control to effectively limit the rate-of-change in load experienced by the generator over the full load range, while also ensuring careful use of the ESD energy, as sufficient energy must be reserved to minimise the rate-of-change of load experienced by the generator at high loads.

The intended overall behavior of the system is summarized in Fig. 1, which also provides the key elements constituting the object of this Call Topic and the power flows in the different phases.

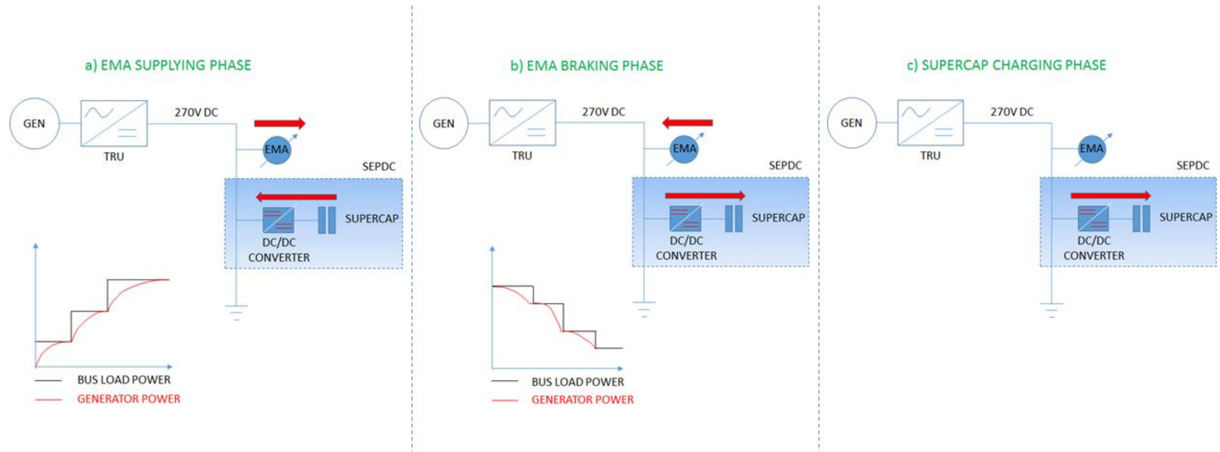


Figure 1: System architecture and power flows (a. EMA supplying phase, b. EMA braking phase, c. Supercap charging phase)

In Fig. 1a, the EMA load is activated, resulting in bus load power sudden variations. In this case, the ESS (DC/DC converter + ESD) shall be able to provide extra power on the HVDC bus, in order to smooth the power peak experienced by the generator correspondent to the EMA power request.

In Fig. 1b, during the EMA braking phase, regeneration energy appears on the bus. In this case, the ESS must be able to absorb the extra power linked to the regenerative effect, managed by the supercapacitor.

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

Given the complexity of the scenario, a strong formal and theoretical approach must be proposed in order to properly define the structure of the energy management strategy, using control methods for rate-limit of the ESS system operations and supervisory control strategies for global coordination of the operations.

Moreover, automatic or semi-automatic technique of translation of the formal structure into a firmware (microprocessor or FPGA) shall be proposed, in order to minimize the chance of programming error.

2.2.3. ESS Requirements

A bi-directional DC/DC converter shall be provided as integrant part of the SEPDC. The converter shall be able to manage bi-directional power flows between the 270 VDC bus bar embed into the SEPDC, and the supercapacitors, recharging them at a predefined voltage (see Fig 1c). The rated power will be provided to the Candidate at early stage of the Project, referring to the Iron Bird network specifications. Reductions of weight and volume by using innovative solutions with respect to the current state of the art are desirable.

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

An adequate number of supercapacitors must be chosen and arranged in order to comply with the energy flows to be managed (i.e. charging and discharging phase). The supercapacitors shall be electrically interfaced with the DC/DC converter, using technical solutions in order to guarantee the installation safety and the correct charge/discharge cycles operations.

2.2.4. EMA requirements

A motor load simulating an Electro Mechanical Actuator representative of a Regional A/C primary surface or main landing gear shall be provided by the applicant, and adequately interfaced with the SEPDC for the purposes of the E^2-EM. The EMA load shall not embed any resistor for energy dissipation, to be instead managed with the ESS. It shall be electrically interfaced with the 270 VDC bus. Moreover, its operation shall be controlled by remote, hence the EMA load shall embed an adequate interface communication with the Iron Bird structure. Finally, its operations shall be monitored and associated measurements shall be available to the Iron Bird network as well as to the SEPDC supervisor.

2.2.5. Environmental Requirements

The SEPDC equipment, including the ESS, and any other equipment referred to in this CfP will be located in a laboratory room for validation and functional tests. Therefore, the environmental requirements shall be limited to a compatibility of the equipment with the laboratory environmental conditions. Anyway, a detailed Interface Control Document (ICD) will be provided to the selected Candidate detailing all the environmental conditions that the module shall comply with.

As an example, as the equipment shall not be installed on the aircraft, the temperature requirement shall be taken into account just for the selection of the appropriate technologies and components and not for a full qualification. The range to be considered for the selection shall be 15 ÷ 40 °C.

2.2.6. Electrical Power Requirements

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

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

The specific power ratings of the SEPDC will be provided to the Candidate at the early stage of the Project. However, they will be compliant with typical Regional A/C power systems and loads.

2.2.7. Operational Requirements

- The system shall continue to work for an acceptable period in case of lack of cooling features.
- FMEA or FMECA analyses shall be provided for failure analyses.
- The system design shall avoid, as much as possible, scheduled maintenance.
- The system shall be able to communicate with a central system for monitoring and control purposes, by means of appropriate protocols (e.g. CAN or ARINC).
- The system shall allow easy reprogramming, by specific ports (e.g. USB or RS232) accessible from a laptop.

2.2.8. Safety Requirements

- The system shall comply with European standards related to electrical power installations, and low voltage electrical installations;
- The system shall embed safety and protections logics (e.g. overcurrents, overvoltages) in order to react to potential failures and communicate the faulty status to an external device.

2.2.9. Software Requirements

During the design phase, the SEPDC and any other equipment referred to in this CfP shall be modeled and tested in a simulation environment in order to pretest their functionalities and performances. Detailed models (preferably SABER models) shall be provided by the applicant, demonstrating the effectiveness of the proposed converter topology by means of accurate simulations. Also the equipment supervisory control and monitoring stategy effectiveness and performances shall be demonstrated by means of simulations, in SABER or other simulation tools. Both “behavioral” and “functional” level models shall be implemented.

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

Tasks		
Ref. No.	***Title - Description***	***Due Date***
KOM	A Kick off meeting will be organized to review the technical requirements and the project logics and organization agreed with the partner during the Grant Preparation phase.	T0
Task 1	Requirements analysis: To review the customer requirements, and describe the equipment to be designed, manufactured, validated and provided to the customer for testing.	[T0 ; T0+ 3M]
Task 2	Converters modelling and simulation: To derive an accurate model of the ESRS with all its components and associated control (low level), suitable for enhanced energy management scopes (both behavioural and functional level).	[T0 + 3M ; T0+ 9M]

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 3	Preliminary Design: To validate the equipment requirements and check that equipment preliminary design is consistent with these requirements: architecture concept according to performance and safety requirements, sizing, interfaces definition, substantiation of design choice.	[T0 + 3M ; T0+ 12M]
Task 4	System behaviour and energy management strategy definition: To analyse, design and theoretically proof the effectiveness of the ESRS and energy management strategy. Software and mathematic tools are required to be used in order to prove the benefits and the formal properties of the designed system and energy management strategy.	[T0 + 12M ; T0+ 16M]
Task 5	Firmware definition and testing: To define the ESRS and energy management strategy as a firmware for the computational core of the supervisor. Simulation based approaches shall be used for proving the firmware correctness in terms of energy management objectives achievement.	[T0 + 16M ; T0+ 21M]
Task 6	Critical Design: To realize the detailed design (mechanical, electrical, thermal, …), realize detailed cad drawings, finalize safety analysis, prior to launch equipment manufacturing.	[T0 + 12M ; T0+ 24M]
Task 7	Manufacturing: To manufacture the ESRS associated equipment, following the CDR documentation.	[T0 + 24M ; T0+ 30M]
Task 8	Testing and validation: To perform the final tests for validating the ESRS actions in terms of energy management objectives achievement.	[T0 + 30M ; T0+ 34M]
Task 9	Optimization and support: To analyse the feedbacks coming from the customer and provide further support for optimization activities.	[T0 + 34M ; T0+ 36M]

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables		
Ref. No.	***Title – Description***	***Due Date***
D1	Analysis phase: Requirements matrix and support documentation	T0 + 3M
D2	ESRS topology and control: Simulation models of the ESRS structure and associated controls	T0 + 9M
D3	PDR: Preliminary Design Review and associated deliverables	T0 + 12M
D4	Energy management definition: Analysis of the results of the simulation models for energy management preliminary tests	T0 + 16M
D5	Firmware specification: Implementation of a preliminary firmware for energy management purposes	T0 + 21M
D6	CDR: Critical Design Review and associated deliverables	T0 + 24M
D7	Installation and commissioning: Delivery of the complete system with its associated documentation (preliminary DDP), installation and commissioning on site	T0 + 30M

D8	Validation final tests and DDP: Validation test report and final results (final DDP)	T0 + 34M
D9	Optimization and support: The CfP Supplier shall support the rig operations to correct potential faults during this probation period	T0 + 36M

Milestones		
Ref. No.	***Title – Description***	***Due Date***
M1	Preliminary Design Review	T0 + 12M
M2	Critical Design Review	T0 + 24M
M3	Final results	T0 + 36M

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

The Candidate organization shall have:

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

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

V. Electro-hydraulic integration of hybrid surface actuation systems in on-ground rigs

Type of action (RIA or IA)	IA		
Programme Area	REG, WP 3.5		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	230 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	36 months	**Indicative Start Date**[19]	Q2 2017

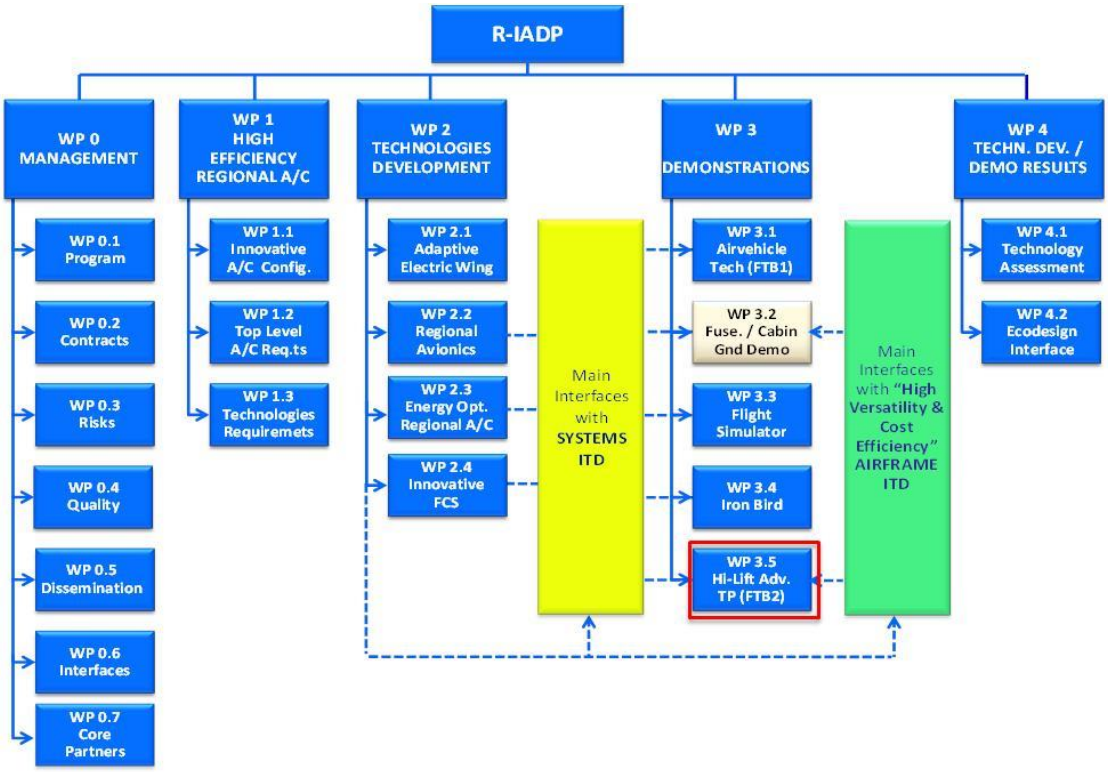
Identification	**Title**
JTI-CS2-2016-CFP04-REG-02-03	**Electro-hydraulic integration of hybrid surface actuation systems in on-ground rigs**
Short description (3 lines)	
The actuation systems of the Regional FTB#2 Demonstrator will combine hydraulic and electrical systems that will be on-ground tested before aircraft installation. The topic deals with design, development and installation of hydraulic installation representative of aircraft in terms of pressure loss and flow rate and instrumentation systems for the on-ground actuation test bench.	

[19] 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 REGINAL IADP *Work Package REG 3.5 High Lift Advanced TurboProp Regional FTB#2 Demonstrator* where this in-flight demonstration platform is prepared. The aircraft control surfaces are actuated by hydraulic and electro-mechanical actuators (EMAs) defined in AIRFRAME ITD work-packages (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. An on-ground test rig is required to integrate the aircraft systems related to actuation and this topic will contribute to the rig: from design to final integration perspective.



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. Figure 5 depicts the FTB2 Demonstrator and the innovative control surfaces actuated by EMAs. The ailerons will have a hybrid system of hydraulic and electrical that allow in the final step to flight with EMA actuation in parallel to hydraulic back-up.

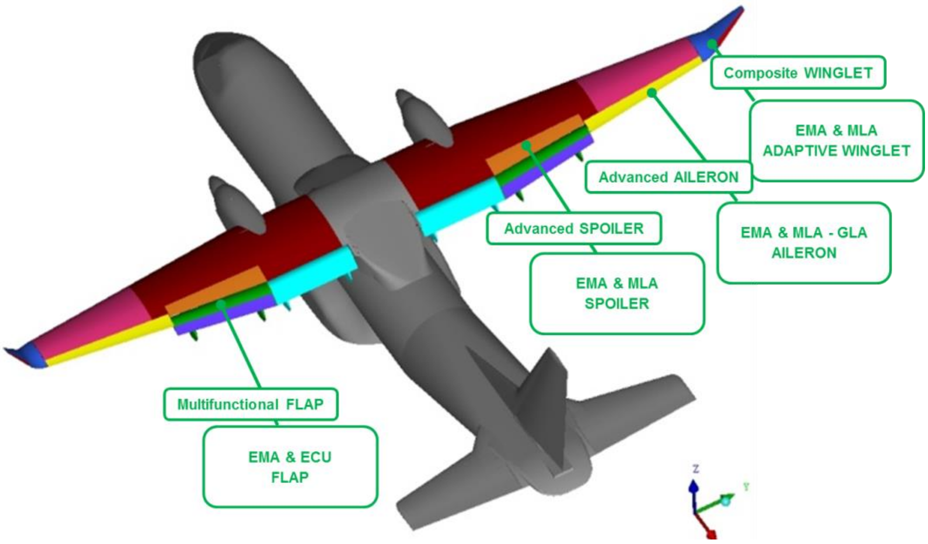
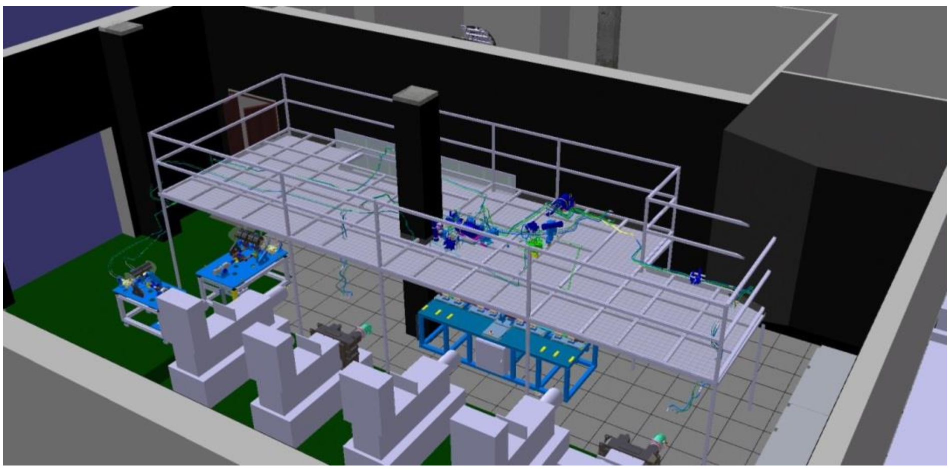


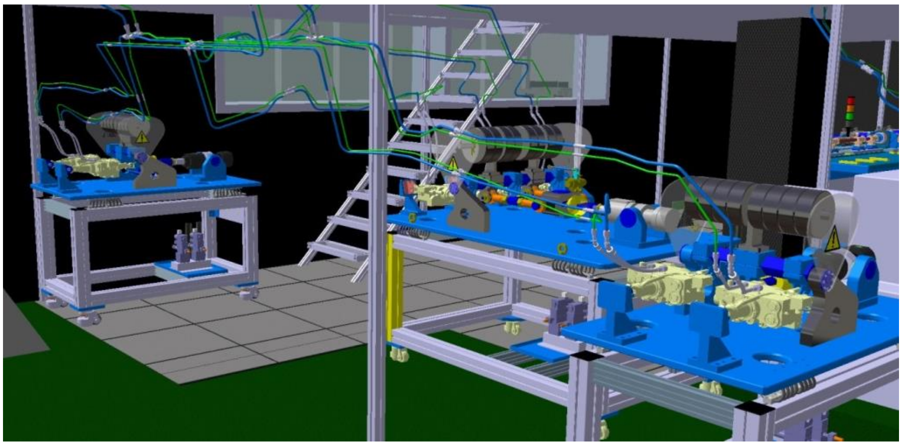
Figure 5: Regional FTB2 A/C innovative control surfaces

2. Scope of work

The objective of this topic is to develop an A/C representative hydraulic installation that integrates all the A/C hydraulic system equipment, considering hydraulic generation and hydraulic distribution, and the corresponding sensors fully representative of flight test instrumentation, in order to reproduce complete A/C conditions that will be present in the Regional FTB#2 Demonstrator. regarding to the actuation of hybrid surfaces as ailerons. The project covers design, manufacturing and power on of the hydraulic systems installation.

The framework of the activities will be the Regional FTB#2 actuation on-ground rig that integrates the aircraft control systems, the electrical systems and the hydraulic. The next scheme show the configuration of the labs where the result of the topic will be integrated.





The hydraulic installation, core of the topic, shall be fully representative of A/C environment, in terms of volume of hydraulic fluid and pressure loss across the different lines, and shall be provide hydraulic supply to the following consumers: elevators (x2), rudder (x1) and ailerons (x2). It shall be considered also the integration with the existing test benches (i.e. elevator, rudder, electrical system, and cockpit) and new ones with high interaction with the electrical systems (i.e. EMA of ailerons, spoiler, flaps and winglet tabs).

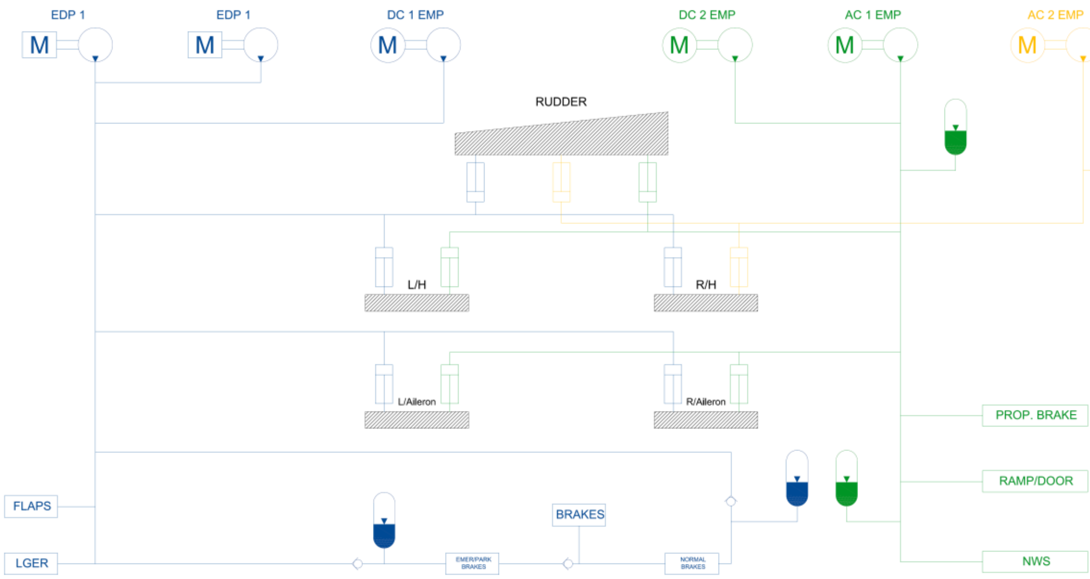


Figure 6. Generic test bench architecture for Hydraulic distribution system

The main objective of the test rig is to evaluate the performance of each component of the hydraulic installation in two modes with switching capability:

- In stand-alone mode the hydraulic system is validated in terms of working under real conditions.
- In integrated mode to evaluate the effects of the hydraulic system in the A/C electrical network, and the response of the complete rig to the commands of the flight controls. 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 equivalent

resistance.

The on-ground hydraulic test bench integrates hydraulically and electrically (if applies) the following A/C equipment:

1. EDP (Engine Driven Pump). At rig facilities, this component will be mechanically assembled to the current gearbox that provides mechanical power both to EDP and A/C generator. The on-ground hydraulic test bench will integrate this element into the hydraulic system.
2. AC & DC Pumps, electrically driven. At rig facilities, these components will be electrically integrated with the electrical system rig and hydraulically integrated into the on-ground hydraulic test bench. A switching capability will be taken into account in order to engage/disengage the actuation of AC & DC Pumps to the electrical system rig.
3. Hydraulic reservoirs for blue, green and yellow lines.
4. Complementary Hydraulic components like manifolds, accumulators, fire emergency shut off valves and filters.
5. Hydraulic servo actuators such as the used at rudder, elevators, flaps and ailerons. These actuators are included in the corresponding test benches, at which are operated at real operational conditions in terms of dynamic loads to be withstand.

The on-ground hydraulic test bench is composed by the following elements:

1. Hydraulic pipes representative of the aircraft circuits, in terms of hydraulic fluid volume and pressure loss, and the corresponding complementary elements (supports, joins…).
2. Innovative FTI acquisition system that includes the sensors of the system (pressure, temperature and flow), considering wireless devices.
3. Hydraulic servo valves that simulate hydraulic customers not present in the hydraulic installation, such as ramp actuator and brakes.
4. Electrical integration –at power and signal level- with the existing rigs –electrical, cockpit-.

The technology challenges of the topic are summarized in the following table.

COMPONENT	TECHNOLOGY CHALLENGES	TECHNOLOGY DEMONSTRATORS
On - ground hydraulic test bench	To investigate the hydraulic consumption and hydraulic network influence during all the operation cases of aileron operation (hybrid actuated surface), including the cases at which the hydraulic generator is fed by electrical system. 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.	On - ground hydraulic test bench integrated with electrical system bench.

COMPONENT	TECHNOLOGY CHALLENGES	TECHNOLOGY DEMONSTRATORS
Innovative FTI acquisition system	To investigate the behavior of innovative wireless FTI systems and their integration into FTI overall system. To elaborate patterns based upon real acquired and elaborated parameters that describe system operation and allow to define maintenance intervals and reduce the workload of FTI engineers.	On - ground hydraulic test bench integrated with electrical system bench, equipped with innovative wireless FTI.

Table 1: Technology challenges in the Flexible Test Rig for different A/C surfaces powered by EMAS

Work Packages and Tasks description

The Topic is organised in one technical Work Package (WP) devoted to on - ground hydraulic test bench.
This 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).

Ref. No.	***Title – Description***	***Due Date***
Task 1.1	KOM: kick off meeting	T0
Task 1.2	Analysis of the mechanical, electrical and control/acquisition requirements	T0 + 1
Task 1.3	Mechanical and Bench Structural calculations	T0 + 2
Task 1.4	Control system definition	T0 + 2
Task 1.5	Trade-off for selection of the industrial elements to be included in the bench	T0 + 3
Task 1.6	Mechanical CATIA design for bench manufacturing	T0 + 3
Task 1.7	SW specification for Control System	T0 + 3
Task 1.8	PDR: preliminary design review	T0 + 3
Task 1.9	CDR: critical design review	T0 + 4
Task 1.10	Manufacturing	T0 + 5
Task 1.11	SW specific development for Control System	T0 + 6
Task 1.12	Acceptance Test Procedure Definition	T0 + 7
Task 1.13	Bench installation at purchaser site	T0 + 11
Task 1.14	CIPS: customer inspection at purchaser site	T0 + 12
Task 1.15	POWER ON: power on of the test bench	T0 + 13
Task 1.16	ATP at purchaser site	T0 + 13
Task 1.17	Support of Rigs Integration	T0 + 36

Table 2: Tasks definition and description of activities

Requirements and Specifications

The new hydraulic test rig shall be fully representative of A/C hydraulic systems, in terms of: volume, pressure losses and simulated customers mass flows.
Once designed the hydraulic distribution systems of the test bench, it shall be validated by the Topic Manager in order to check the pressure drops and volume required to be fully representative.

Less costing materials, components and pipes as well as sensors may be considered if the properties of each element is similar to A/C equipment and its behaviour is equal, previously agreed with the work package leader.
This 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, switching capability in terms of power and signal lines respectively shall be assured.
In all the cases the necessary A/C connectors shall be provided in order to connect A/C equipment.
This test bench shall consider the installation of a control system in order to acquire and command the different signals that are included in the test rig, in an external rack:

- This control unit shall be based upon a NI and/or BECKOFF HW, in order to assure compatibility with the rest of the benches to which it will be integrated.
- Control system shall be developed by using National Instruments SW based on Labview tool.
- The SW code shall comply with the corresponding specifications and also shall be provided open code in order to allow further modifications if required in the future.

At signal lines, patch panels shall be provided, with manual and automatic switching capability, in order to simulate the corresponding failures and validate the response of the complete hydraulic system withstanding and also electrical network influences.
Regarding to the modes of operation of the bench:

- In stand-alone mode, AC & DC hydraulic power supplies with enough capacity shall be provided to AC and DC pumps, in order to allow them to work disengaged from electrical system.
- In integrated mode, AC & DC hydraulic power supplies are connected to the electrical system rig

Every equipment 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, the 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 each component.
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, temperature and mass flow 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 D38999 series or equivalent 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 V15)
- 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.

COMPONENT/ACTIVITY	Effort estimated
Mechanical desing, manufacturing, installation and power on	60%
FTI system architecture, component selection and integration	30%
Development of Control SW	10%

Table 3: Effort required for each main component/activity within the project

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 On - ground hydraulic test bench with capacities described

3. <u>Major deliverables/ Milestones and schedule (estimate)</u>

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. The topic activity is highlighted within a red box. In addition there are leader activities and other Partners activities linked to the aircraft rig demonstrator.

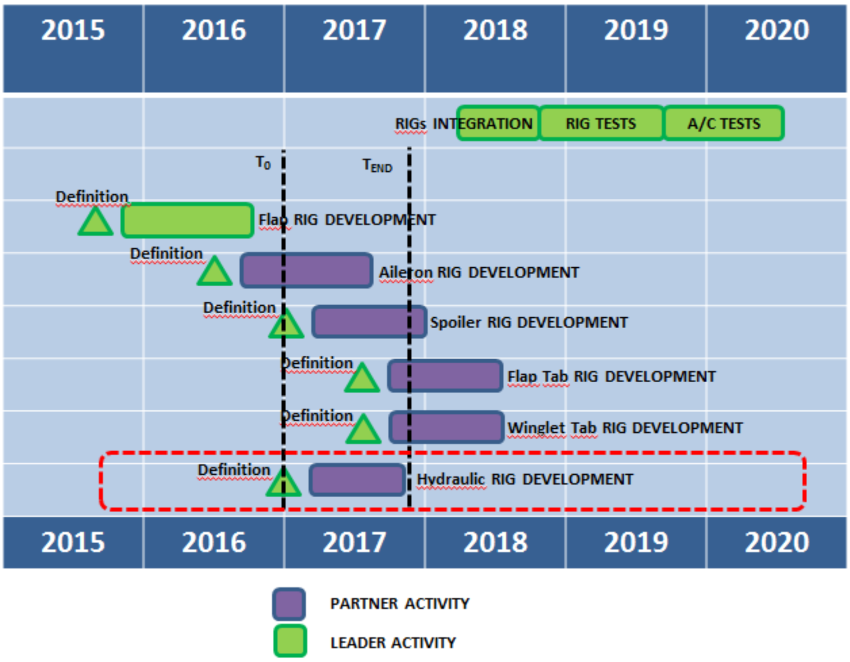


Figure 7. Planning for the Regional Aircraft FTB2 vs Hydraulic Rig Development, including the different benches under development. Activities of Leader and Partners. (Best estimation at publication date)

List of FTB2 Demonstrator Principal Milestones

Ref. No.	*Title - Description*	*Due Date*
M0	**Test Bench KOM**	T0
M1	Test Bench PDR	T0+3
M2	Test Bench CDR	T0+4
M3	Test Bench CISS	T0+12
M4	**Test Bench POWER ON**	T0+13

List of Main Deliverables

Ref. No.	*Title – Description*	*Type*	*Due Date*
D1	KOM: kick off meeting	Document	T0
D2	Analysis of the mechanical, electrical and control/acquisition requirements	Document	T0 + 1
D3	Mechanical and Bench Structural calculations	Document	T0 + 2
D4	Control system definition	Document	T0 + 2

Ref. No.	Title – Description	Type	Due Date
D5	Trade-off for selection of the industrial elements to be included in the bench	Document	T0 + 3
D6	Mechanical CATIA design for bench manufacturing	CATIA model	T0 + 3
D7	SW specification for Control System	Document	T0 + 3
D8	PDR: preliminary design review	Document	T0 + 3
D9	CDR: critical design review	Document	T0 + 4
D10	SW specific development for Control System	Document + SW Files	T0 + 6
D11	Acceptance Test Procedure Definition	Document	T0 + 7
D12	CIPS: customer inspection at purchaser site	Document	T0 + 12
D13	ATP at purchaser site	Document	T0 + 13

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 Leader, 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
AC	Alternate current
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
DC	Direct current
EMA	Electro Mechanical Actuator
EDP	Engine Driven Pump
FTI	Flight Test Instrumentation
HA	Hydraulic ActuatorICD Interface Control Document
JTP	Joint Technical Programme
KOM	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

3. Clean Sky 2 – Fast Rotorcraft IADP

I. Hydrophobic Windscreen Protection for Next Generation Civil Tilt Rotor

Type of action (RIA or IA)	IA		
Programme Area	FRC– WP 1 [NextGenCTR Demonstrator Tiltrotor]		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	750 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	36 months	**Indicative Start Date**[23]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-FRC-01-11	**Hydrophobic Windscreen Protection for Next Generation Civil Tilt Rotor**
Short description (3 lines)	
The present activity involves the design, development, manufacture, testing and flight qualification of hydrophobic coating protection system to be applied on Next Generation Civil Tilt Rotor wiperless windscreens.	

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

1. Background

In the framework of Clean Sky 2 FRC IADP, the present Call requires Partner(s) (company or consortium) to design, develop, manufacture, test and qualify an hydrophobic coating to be applied on Next Generation Civil Tilt Rotor windshield system to eliminate the need for wiper system.

2. Scope of work

The hydrophobic coating to apply on windshield shall be designed in such a way that the main system functionalities and performances are guaranteed throughout the whole flight envelope, whilst ensuring adequate safety levels and environment protection.

The Partner(s) shall therefore perform an investigation among suitable technologies (TRL 4 as a minimum) for the hydrophobic coatings, with the objective to achieve the following performances and functionalities:

- Coating shall eliminate the need for wipers and shall prevent unnecessary scratching;
- Coating should be capable of cleaning from the windscreen surface any accumulation of water in rain intensities up to 100mm/hour;
- Coating shall be capable of cleaning from the windscreen surface any accumulation of water, insects, dirt, sand, dust or salt spray, thin coat of soft snow;
- Coating shall be able to function with no harmful effects derived by the flying in snow and/or icing conditions, and moisture;
- Coating shall be compatible with existing windshield technologies;
- Coating shall be chemical-resistant (acid, cleaners, oil, jet fuel, etc.);
- Coating shall be unharmful;
- Coating shall be >99% transparent across visible spectrum with less than 0.5% haze;
- Coating shall be ice-phobic (nice to have);
- Coating shall minimize the maintenance effort.

Coating shall be either based on windshield surface treatment, or additional dedicated material film application, or any other suitable meaning compatible, as a minimum, with:

- Acrylic
- Polycarbonate
- Polyurethane
- Glass

The coating shall be entirely suitable for the purpose intended, and shall take into account the effects of the environmental conditions expected in service:

- All weather conditions, in all parts of the world;
- Operating temperature range of -55 °C/+55°C;
- Soak (non-operating/storage) temperature range of -60°C/+85°C;
- Operate altitude range of -2000ft/30000ft;

- Commercial aviation cleaning fluids.

The coating shall consider accessibility for inspection, repair and maintenance with minimum disassembly of the equipment. The assembly shall be easily maintained and shall permit inspection, removal and repair by semi-skilled individuals.

Unit shall be designed in order to avoid the use of “Special tools” for installation, servicing, inspection and testing. Where the use of special tools is unavoidable, the Partner(s) shall seek permission from FHD for the use of such tooling. Following permission, these tools will then be considered as a contractual design and hardware deliverable from the Partner(s) with the same milestone and schedule as the coating system itself, as defined in the below tables.

The coating system shall be qualified for the installation on NGCTR as per DO-160 rotorcraft environmental requirements, and shall include a mean to identify the system operability before take-off and throughout the flight.

At the end of the design and development phase, all the evidences necessary to achieve system flightworthiness qualification shall be provided to FHD, together with a production shipsets and spare parts for flight test activity on NGCTR in a number to be defined at the System Concept Review.

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

The design, the development and the qualification of the system shall follow the standard procedures for aeronautic equipment, aimed of obtaining Experimental Flight Approval (EFA) for the installed item.

Tasks		
Ref. No.	***Title - Description***	***Due Date*** [T0 + mm]
T01	System Definition(1)	T0
T02	Trade-off study results	T0 + 06
T03	Design Architecture Definition	T0 + 12
T04	Delivery of Design Documentation	T0 + 16
T05	End of Testing Activity for EFA	T0 + 30
T06	System qualification	T0 + 36
T07	Support to Aircraft Activities	T0 + 36

(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 FHD 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-off study results report	REPORT	T0 + 06
D02	Hydrophobic Coating Specification	REPORT	T0 + 06
D03	Preliminary 3D models and layout drawing	CATIA FILES and DRAWINGS	T0 + 12
D04	Qualification program plan (QPP)	REPORT	T0 + 12
D05	Development plan (DP)	REPORT	T0 + 12
D06	Performance analysis	REPORT	T0 + 12
D07	Preliminary Reliability and FMEA	REPORT	T0 + 12
D08	Reliability and FMEA	REPORT	T0 + 16
D09	Failure Modes, Effect and Criticality Analysis (FMECA)	REPORT	T0 + 16
D10	Safety/Hazard Analysis	REPORT	T0 + 16
D11	Final 3D models and layout drawing	CATIA FILES and DRAWINGS	T0 + 18
D10	Development Shipsets availability	HARDWARE	T0 + 18
D11	Qualification Test Procedures (QTP)	REPORT	T0 + 24
D12	Qualification by Similarity and Analysis (QSAR)	REPORT	T0 + 24
D12	Acceptance Test Procedures (ATP)	REPORT	T0 + 24
D13	Acceptance and Qualification Test Reports	REPORT	T0 + 36
D14	Guidelines on requirements for development of ICA	MANUAL	T0 + 36
D15	Production and Spare units, and relevant Data Conformity Documentation	HARDWARE and REPORT	T0 + 36

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

Milestones			
Ref. No.	***Title - Description***	***Type***	***Due Date*** [T0 + mm]
M01	Kick-off meeting	DESIGN REVIEW	T0
M02	System Concept Review	DESIGN REVIEW	T0 + 06
M03	Preliminary Design Review	DESIGN REVIEW	T0 + 12
M04	Prototype unit ready for development tests	HARDWARE AVAILABILITY	T0 + 18
M05	Critical Design Review	DESIGN REVIEW	T0 + 18
M07	First Article Inspection	DOCUMENT	T0 + 24
M08	Test Readiness Review	DESIGN REVIEW	T0 + 24
M09	Production units and spare units delivered to FHD for flight tests	HARDWARE AVAILABILITY	T0 + 36
M10	Declaration of Design and Performance for EFA	DOCUMENT	T0 + 36

Milestones			
Ref. No.	***Title - Description***	***Type***	***Due Date*** [T0 + mm]
M11	Qualification closure	DOCUMENT & DESIGN REVIEW	T0 + 36

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

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

The Partner(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 equipment, according to RTCA-DO-160 (or other civil or military equivalent standards) for safety critical equipments.
- Experience in research, development and manufacturing in the following technology fields:
    - hydrophobic coating to apply on windshield aircraft
- 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.
- Shape, component design and structural analysis using CATIA V5 R22, NASTRAN, Matlab or equivalent software.
- Capacity to optimize the HW 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.

5. Abbreviations

NGCTR	Next Generation Civil Tiltrotor
FMEA	Failure Mode and Effect Analysis
FHD	Finmeccanica Helicopter Division
HW	Hardware

II. Flight Critical Wireless Slip Ring for a Civil Tiltrotor

Type of action (RIA or IA)	IA		
Programme Area	FRC – WP 1.1, WP1.2 [NextGenCTR Demonstrator Tiltrotor]		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	750 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	48 months	**Indicative Start Date**[25]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-FRC-01-12	**Flight critical wireless slip ring for a civil tiltrotor**
Short description (3 lines)	
The objective is to develop and deliver flight critical wireless slip ring 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.	

[25] 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. A large scale flightworthy demonstrator embodying the new European tiltrotor architecture will be designed, integrated and flight tested.

The outcome of this project is substantiation of a flight cleared wireless slip ring unit integrated into a proprotor system. Slip rings are necessary for monitoring and control of flight-critical electrical equipment in the proprotor system. Additionally, during experimental flight activities, slip rings are required to transmit instrumentation data across the rotating to non-rotating systems boundary. The slip ring is required to deliver sufficient power to the rotating system to operate the rotating portion of the slip ring and the electronic control and data management systems in the rotor. Wireless slip rings are highly desired for their high bandwidth and reliability capabilities to support flight-critical signals and/or large volumes of experimental data.

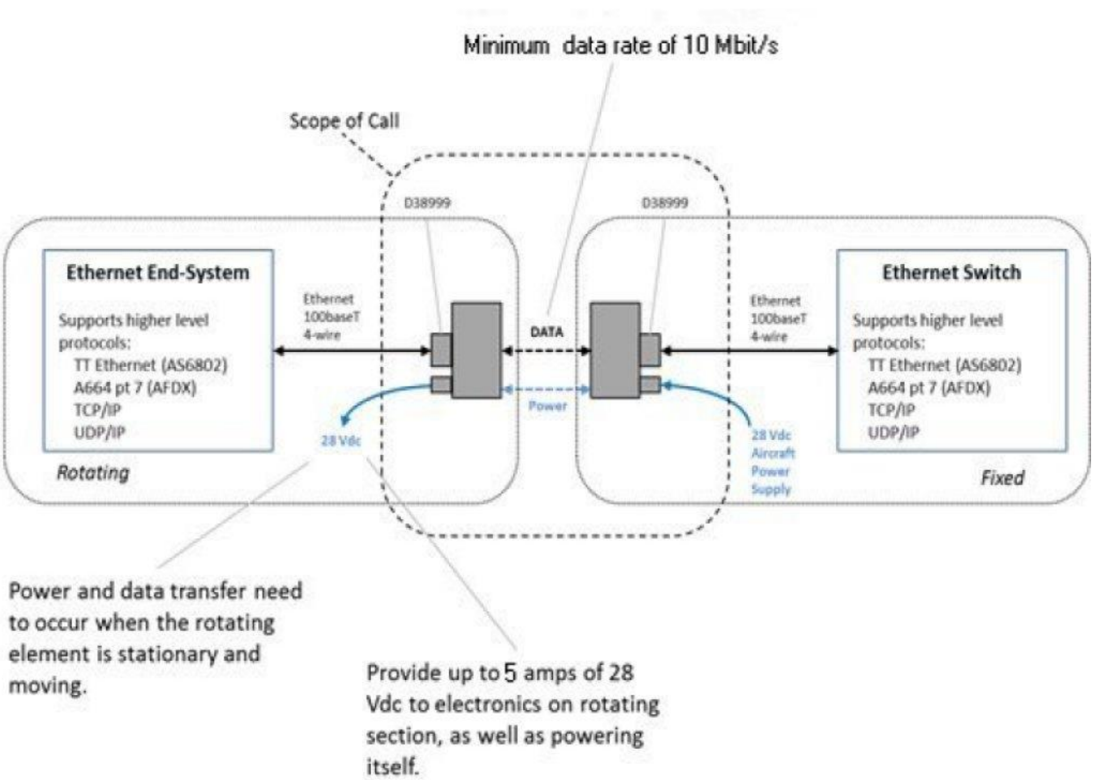


Figure 8: Schematic Diagram
For illustration purposes only, design subject to change

<u>Note: Preliminary allowed geometrical envelop and electrical/mechanical interfaces shall be provided to the interested applicants after signature of a dedicated Non Disclosure Agreement.</u>

2. Scope of work

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

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 wireless slip ring 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 wireless slip ring unit design according to characterisation test results and evolution of the overall rotor design	T0+24 -T0+30
T5	Manufacture of prototype for Safety of Flight testing	T0+30 -T0+36
T6	Safety of Flight 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:

- Designs that include a wireless slip ring integrated with the hub will be considered.
- Connector Interfaces:
    - Rotor: D38999
    - Fixed System: D38999
- Data bandwidth: payload of minimum 10 Mb/second
- Power transmission: 5 A @ 28 Vdc
- Designed to comply with RTCA-DO-160, RTCA-DO-178 and RTCA-DO-254 (or other civil or military equivalent standards) for safety critical equipment.
- Damage tolerant design that complies with (EASA CS-29) civil certification requirements.
- Minimum weight to fulfil functional requirements

Task T2:

Representative specimens 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 representative elements will be conducted to validate performance of the chosen configuration under the expected environmental conditions.

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 wireless slip ring 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 one prototype wireless slip ring unit will be manufactured for safety of flight testing at a location agreed between the Partner and the Topic Manager, and two (2) prototypes for the aircraft ground test article.

Task 6:

Structural testing of the representative specimens will be conducted to validate operation and structural endurance in the rotor system vibratory environment. 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 four (4) off wireless slip ring 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 wireless slip ring.

General Remarks:

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

Development of the wireless slip ring 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 performance characteristics	Document/Report	T0+24

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D5	Availability of prototype for Safety of Flight testing	Hardware	T0+36
D6	Safety of Flight 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 Safety of Flight testing	Hardware Availability	T0+36
M6	Safety of Flight Test Report	Document	T0+42
M7	Delivery of flight hardware for installation into Rotor Assy	Hardware Availability	T0+46
M8	Flight Clearance (TRL-6 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 wireless slip ring and the constituent materials . Therefore the Partner has to provide all documentation necessary to achieve "Permit to Fly", including:

- Compliance to SAE AS9100.
- Experience of aeronautic rules, certification processes and quality requirements.
- Experience in design, validation, manufacturing and environmental/functional qualification of airborne equipment, either cockpit flight control systems, avionics systems (embedding complex HW and DAL-A SW) or both, according to RTCA-DO-160, RTCA-DO-178 and RTCA-DO-254 (or other civil or military equivalent standards) for safety critical equipment.

- Experience in Safety assessment process according to SAE-ARP-4754 and SAE-ARP-4761 standards, willingness to interact closely with TM safety specialists in order to produce the necessary outputs (safety and reliability reports and fault trees/analyses).
- 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).
- 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 6 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 wireless slip rings.
- Design, analysis and configuration management tools of the aeronautical industry (i.e. CATIA v5 release 22, 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.
- 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.
- EASA Design Organization Approval (DOA) is desirable
- EASA Product Organization Approval (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).

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

Technology Readiness

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.

III. Bird strike - Erosion resistant and fast maintainable windshields

Type of action (RIA or IA)	IA		
Programme Area	FRC– WP 2.2 [LifeRCraft]		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	600 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	50 months (24 w/o support to flight test)	**Indicative Start Date**[27]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-FRC-02-16	**Bird strike - Erosion resistant and fast maintainable windshields**
Short description (3 lines)	
A complete set of lightweight windshields for the Fast Rotorcraft has to be developed, manufactured and tested. This encompasses both sides of the front area as far as the upper pilot- and the lower-windshields. It is an opportunity to develop a lightweight innovative windshield fulfilling the requirement of a non-pressurized high speed rotorcraft aircraft (bird strike resistant, low drag, compatible with water repellent treatment…)	

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

1. Background

High Speed demonstrator, expanded flight envelope, low drag design, bird strike resistance, enhanced maintainability

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

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

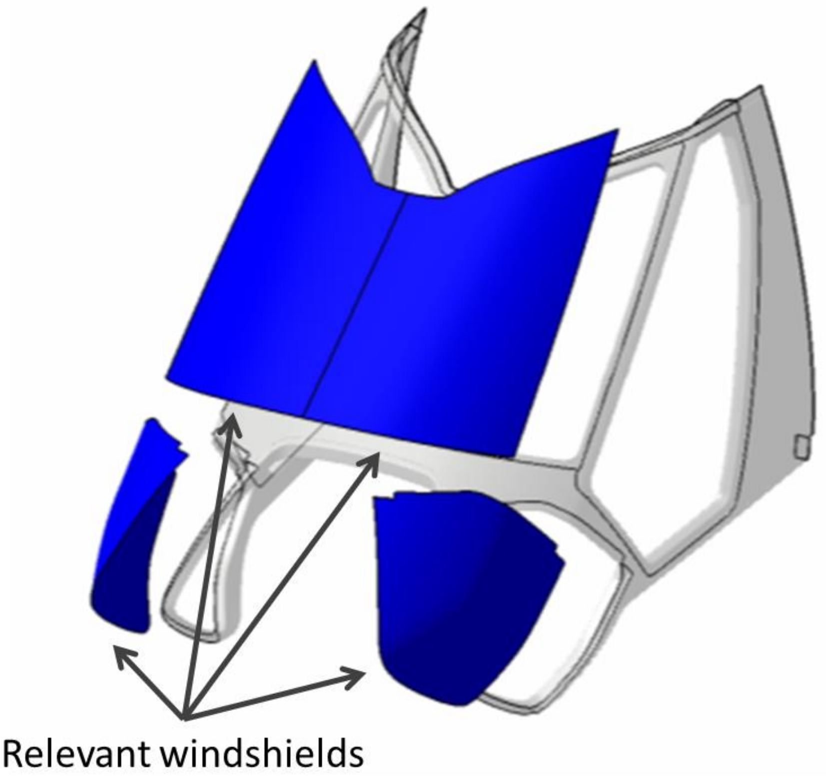
In addition to the complex vehicle configurations, Integrated Technology Demonstrators (ITDs) will accommodate the main relevant technology streams for all air vehicle applications. They allow the maturing of verified and validated technologies from their basic levels to the integration of entire functional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

2. Scope of work

Innovation target is to achieve a weight reduction of 40% for double-curved bird strike resistant windshields with included and improved de-fogging and de-icing capability, fast maintainability, long-term scratch resistance with optimal optical quality and compatible with water repellant treatment which will enable to avoid the use of wipers.

Helicopter windshields have to ensure superior optical quality and bird strike resistance (only CS29 types) under all kinds of environmental conditions and operations. Today, these requirements cause tremendous extra cost and weight. For instance: Before take-off, De-Fogging and De-Icing of helicopters is realized by air conditioning that leads to long-time delay and (unnecessary) high fuel consumption. During operation, polymeric windshields suffer under insufficient scratch resistance that causes frequent demand for repair/exchange of windshields by/at the customers. These requirements induce additional weight to recent heavy double curved windshield design granting sufficient bird strike resistance.

The subject of this Call for Partners are all the activities needed for developing and manufacturing the windshields of the LifeRCraft Demonstrator as part of the ITD Airframe for further application and use in the High speed Rotorcraft LifeRCraft IADP. Therefore activities such as engineering activities, manufacture and test are to be performed in this call. In addition to the technical activities the relevant management activities have to be performed also.



Tasks		
Ref. No.	***Title – Description***	***Due Date***
1	Development, layout, design and certification of the windshields for a High Speed H/C. Features to be included: • Bird strike resistance according to CS29 • Optimized for Pilot's view capability • Superior optical quality • Scratch/abrasion resistance (also gravel, wisher/wiper) • Light weight design • Easy and fast maintainability and assembly (bonding) • De-fogging capability (coating) • Repellent characteristics • Compatible with electrical anti-icing • Low recurring costs • Media resistance • Noise reduction • HUD compatibility (only for the upper pilot windshields) • Mitigation laser threats The development has to be done in close cooperation with the Topic Manager	T0+15
2	Manufacturing of left and right pilot windshields for test article	T0+12
3	Manufacturing of left and right lower windshields for test article	T0+12

Tasks		
Ref. No.	***Title – Description***	***Due Date***
4	Testing of the windshields will comprise e.g. optical quality, scratch resistance, bird strike…	T0+15
5	Delivery of left and right pilot windshields for FRC	T0+16
6	Delivery of left and right lower windshields for FRC	T0+16
7	Support to installation	T0+16
8	Contributing to obtain the permit to flight Contributing to obtain permit to flight documentation for the windows	T0+18
9	Support to flight test campaign	T0+44

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Concept for windshields (materials, coatings, composite approach, de-fogging, de-icing, etc.)	Doc	T0+04
D2	Concept for windshields assembly + maintainability	Doc	T0+04
D3	Detailed drawings	Doc	T0+10
D4	Windshields (hardware) for Mock-up	HW	T0+18
D5	Windshields (hardware) for FRC	HW	T0+16
D6	Contributing to "Permit to Fly"	Doc	T0+18
D7	Report about lessons learnt from flight test	Doc	T0+44

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	PDR	MS	T0+04
M2	CDR	MS	T0+12
M3	Flight test survey	MS	T0+44

Due to the tight schedule there is the possibility to delivery previous set of the relevant windshields for the early test flight without additional innovation. Of course the set of windshields have to perform the requests of high speed test flights (especially bird strike resistance etc.).

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

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

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

Weight:

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

Recurring cost estimation:

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

Data management:

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

- CATIA V5 R21
- VPM
- Windchill

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

Eco-design

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

Special Skills

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

- Experience in design, manufacturing and testing of polymeric transparencies (M).
- Design, analysis and configuration management tools of the aeronautical industry (i.e. CATIA v5 release 21, NASTRAN, VPM) (M).
- Competence in management of complex projects of research and manufacturing technologies (M).
- Experience with TRL Reviews or equivalent technology readiness assessment techniques in research and manufacturing projects for aeronautical industry (M).
- Proven experience in collaborating with reference aeronautical companies with industrial air vehicle developments with “in – flight” components experience (M).
- Capacity to support documentation and means of compliance to achieve experimental prototype “Permit to Fly” with Airworthiness Authorities (i.e. EASA, FAA and any others which may apply) (M).
- Capacity to specify material and structural tests along the design and manufacturing phases of aeronautical components, including: material screening, panel type tests and instrumentation (M).
- Capacity to perform structural and functional tests of aeronautical components: test preparation and analysis of results (M)
- Capacity to repair/rework “in-shop” components due to manufacturing deviations (M).
- Capacity of performing Life Cycle Analysis (LCA) and Life Cycle Cost Analysis (LCCA) of materials and structures (A).
- Capacity of evaluating design solutions and results along the project with respect to Eco-design rules and requirements (A).

- Design Organization Approval (DOA)(M).
- Product Organization Approvals (POA)(M).
- Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004)
- Qualification as Material and Ground Testing Laboratory of reference aeronautical companies (i.e. ISO 17025 and Nadcap)(M).
- Technologies for polymeric material manufacturing (M).
- Mechanical processes, regarding assembly of windshield to surrounding structure (M).

Material and Processes

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

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

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

The TRL review must be held within one year after beginning of the project and must confirm a maturity of TRL5 or at least TRL4 if a solid action plan to reach TRL5 within the scope of one further year and finally meet the TRL target for the demonstrator is validated and accepted by AH. Furthermore, since the schedule of the project and the budgetary framework don't allow for larger unanticipated changes in the middle of the project, it is required that at the start of activities the partner demonstrates his capability to develop and manufacture the required items with a baseline technology (which can be e.g. PMMA or PC windshields with established coatings and adhesives as well as screwed windshield frames) which will be a back-up solution if the new technology to be introduced, proves to be overly challenging. There is the possibility to deliver a previous set of the relevant windshields for the early test flights without additional innovation. Of course this previous set has to fulfil all requests for a "Permit to Fly".

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

Due to the location of the windshields in the front of the H/C special attention should be given to a weight-optimized solution for the windshield materials and the installation concept.

With regards to a potential serial application the RCs (recurring costs) should be taken into consideration through the complete development process starting from the concept phase.

Furthermore all selection of concepts and materials should be made within the framework of an eco-design approach with a special attention to ecological topics.

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

Certification:

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

IV. Flight Management System Providing Noise Abatement Flight Procedures for Compound Rotorcraft

Type of action (RIA or IA)	IA		
Programme Area	FRC– WP 2.12 [LifeRCraft]		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	1000 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	45 months [until end of LifeRCraft demo flights]	**Indicative Start Date**[28]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-FRC-02-17	**Flight Management System Providing Noise Abatement Flight Procedures for Compound Rotorcraft**
Short description (3 lines)	
The aim of this call of proposal is to design, develop, manufacture, test and qualify a flight management system which will fulfill requirements that consist on providing complex flight trajectories for compound aircraft in order to minimize noise footprint, and thus improve environmental friendliness in urban environment, by maintaining a high level of safety.	

[28] 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 environment protection and citizens' wellbeing better than conventional helicopters.

In order to improve relationship between helicopter operations and citizens environment, progress axes have been identified. One of these axes is to reduce noise footprint of LifeRCraft. This may be realized by optimizing flight management system procedures in order to obtain major improvements. Limiting noise annoyance for inhabitants will enhance the compound rotorcraft operations perception. Additionally it will allow operations in urban area such for heliports, building and hospital helipads with efficient transport that respects the environment. The definition of flight approach procedures within flight management system is a section among others that may conduct to results by standardizing specific flight path profiles.

2. Scope of work

The scope of work consists on designing, developing, manufacturing, testing and qualifying a flight management system for specific low noise trajectories. The definition of instrument approach procedures will be realized in close collaboration between topic manager and partner according to environment acoustic analysis and compound aircraft specificities. The trajectory may include straight and curved approach. Complexity of curved approach supports the need of FCS coupling to perform the path, and reduce piloting workload.

In addition assessment of procedure coding has to be assessed, especially for approach phase. The display of the path, modification of the path with relevant control and moding will be assessed, including the need of graphical interaction.

The constraints on the integration include

- the interface with the avionics system especially the interface with the display and flight control based on A429 Gama type interface (Arinc 429 Gama adding additional labels used by basic avionics to allow display of flight plan as 3D/4D data and special pattern), for which changes have to be minimized.
- the GNSS sensor is an Arinc743B GNSS receiver.
- radio control capability with PROLINE21

The FM shall manage multinavigation (GNSS, radio navigation VOR/DME, DMEDME, coasting capability in case of GNSS loss) The FM shall provide approach capability down to LPV minima in a delta-4 architecture.

The size of the control and display unit (conventional CDU with graphical display,) must not exceed the width of an Arinc739A CDU typically size about 14.5cm width 17,1 cm, to be installed on the interseat console. Other size can be considered, provided it can be installed on the interseat console. The touchscreen based control device unit shall include technologies to obtain the necessary safety level and meet the environmental requirements specific to helicopter applications.

The flight management system has to comply with approach requirement of civil regulations AMC20-27, and

AMC20-28, to manage approaches as required by IFR rules, and noise abatement procedures will be added to this capability.

The low noise abatement procedure should be isolated to allow easy change and tuning of the function during the development
For touch screen application, control and moding of radio navigation and communication equipments should also be isolated to allow evolution and possible change by a third party.

For all listed tasks below as it will not be repeated constantly the candidate has to focus firstly on safety objective.

Task 1:
The candidate shall identify flight management computers if they are re-used ones that enable to embed additional calculations within the software in order to fulfill complex flight path trajectories requirements i.e. he has to ensure that current computer performances capability may respond to a growth potential (additional software computations, additional communication exchanges in existing lines,…).

Task 2:
In order to comply with avionics interfaces the flight management computers shall interface to Helionix avionics suite with limited changes. The interfaces foreseen to be used are the following ones: A429 output and input with display system according to the Helionix standard (flight plan output frame derived from Arinc 429 Gama standard, with additional information for display and flight control system). No exotic interface communication solutions which are not able to fulfill navigation development assurance level in phase with aeronautical regulations will be accepted, in order to limit risks and changes.

Task 3:
As it is difficult to foresee today the type of low noise flight path profile, the candidate will provide a mean, a loading tool and a user manual in order to enable the topic manager to have a way to configure the flight path parameters within the flight management computer in its own bench test facilities. This mean may be for example a configuration table modifiable and loadable by a loader software tool. This table, to stay in the mentioned example, will be set in close collaboration between partner and topic manager in order to identify all needed parameters for the new features of the upgrade flight path.

Task 4:
The candidate will have to define the guidance functions responsible for producing commands to guide the aircraft along the defined flight path profile with criteria specified in collaboration with the topic manager. It has to be consider that it may be possible that the guidance functions will be not restricted only to lateral and vertical path, but may include speed control (horizontal and vertical) or acceleration and possibly more complex interface to follow the path minimising the noise level.

Task 5:

For simulation purpose it may be required a delivery of a software model in order to integrate in pure numerical avionic simulation. The model will be integrated in different operating system targets. It shall be representative of the real embedded software in terms of functions and interfaces to fit with retargeted simulation objectives and with the simulation function that allows to switch between real equipment and simulated model use.

Task 6:

The architecture of the flight control guidance and navigation consists in order to answer to safety requirements and development assurance level on:

- A duplex (2 computers) multi sensors Flight Management System
- 1 or 2 GPS according to progress in choice of aircraft configuration

The partner shall fit to a solution that respond to equivalent requirements declined by the above functions list. The design will ensure “En route”, “Terminal” and “Approach” guidance, and answer to the following guidance modes: Direct to, Radial to, Holding patterns, Parallel tracks, Route discontinuity, Fly over / fly by, SID & STAR procedures, Search patterns, Guided transition down; And allows to compute present position, guidance data and flight planning. The architecture has to manage radio communication and other communication with such existing equipments:

- VHF4000
- HF9000
- DME4000
- NAV4000 (VOR/ILS/ADF)
- NAV4500 (VOR/ILS)
- TDR 94D
- ACAS
- Multi function displays
- Flight control system
- Vehicle mangement system
- Air data computer
- GPS
- transponder
- RNAV sensors concentrator

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D0	Inputs Delivery by the Topic Manager	Doc	T0
D1	Flight management system	HdW	T0
Associated documents for Deliverable D1 – first version			
D1.1	System specifications	Doc	T0+2
D1.2	Interface requirements specifications	Doc	T0+2
D1.3	Maintainability – installation specifications	Doc	T0+2
D1.4	Safety and reliability specifications	Doc	T0+2
D1.5	Performances specifications	Doc	T0+2
D1.6	Environmental specifications	Doc	T0+2
D1.7	Certification and qualification requirement specifications	Doc	T0+2
D1.8	Safety and reliability analysis	Doc	T0+2
D1.9	Installation Design Document (IDD)	Doc	T0+2
D1.10	Interface Control Document (ICD)	Doc	T0+2
D1.11	Installation manual	Doc	T0+2
D1.12	Assembly drawing	Doc	T0+2
Rig tests			
D2.1	SW release deliveries to be downloaded into FMS computers	Sw	T0 to T0+45
D2.2	SW release document deliveries to be downloaded into FMS computers	Doc	T0 to T0+45
D2.3	Definition of software configuration table (or other mean)	Doc/Sw	T0+3
D2.4	Software loader tool to manage new features of flight path parameters (or other mean)	Sw	To+3
D2.5	Physical wiring/cable between loader tool and computers (or other mean)	HdW	T0+3
D2.6	Software for numerical simulation for linux, windows operating systems	Sw	T0+3
D2.7	Test plan	Doc	T0+12
D2.8	Test procedure	Doc	T0+12
D2.9	Test report	Doc	T0+20 to T0+45
Flight tests			
D3.1	Computers good for flight	HdW	T0+10

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D3.2	Software good for flight	Sw	T0+20 to T0+45
D3.3	Permit to fly documents	Doc	T0+20 to T0+45
D3.4	Software releases and release notes deliveries - good for flight	Sw/Doc	T0+10 to T0+45
Synthesis and serial vision			
D4.1	Synthesis report	Doc	T0+39 to T0+45

Milestones			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Kick off Meeting	Review	T0
M2	Progress report	Report	Each 2/3 months according to progress
M3	Progress review	Review and Approval	Periodic according to progress report
M4	PDR, CDR	Review and Approval	According to avionic planning
M5	Support to rig tests	Support	T0+3 to T0+45
M6	Support to simulation	Support	T0+2 to T0+45
M7	Support to flight tests	Support	T0+26 to T0+45
M8	All needed data for "permit to fly"	Report	T0+20 to T0+45
M9	Synthesis and extrapolation to serial product Report	Rewiew and Report	T0+26 to T0+45

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

- Providing material data which are required to achieve a "Permit to Fly";

- Using material, processes, tools, calculation tools etc. which are commonly accepted in the aeronautic industry and certification authorities;
- Facilitating harmonization of calculation processes/tools with the Topic Manager;
- Acting interactive with the Topic Manager at any state of work;
- Giving access to the production and test sites;
- Performing the updates of documentation in case of in-sufficient documentation for authorities;
- Checking TRL level 4 is reached for each system/technology upon project start (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, testing and certification of flight management system.

- 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).
- In addition following skills and capabilities are expected from the Applicant:

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

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).

All requested tasks have to fulfill aeronautic standards and guidelines linked with particular aeronautical activities. For instance, all data required for a permit to fly will be delivered. And the activities shall be thought and designed in order to fulfill:

- DO178B standard with development assurance level according to safety analysis for software,

- RTCA-DO200-A for navigation data base,
- TSO C115c and C129a class B1/C1,
- TSO C113 for data entry and display,
- DO160E is taken account for Environmental Conditions and Test Procedures for Airborne Equipment,
- DO254 for Digital Devices

Export Regulations

- Preferably, delivered material/software should only be subject to European Union Dual-Use export control Regulation (EU Regulation n°428/2009 updated by the EU Regulation n°1382/2014);
- For delivered material/software subject to any export control laws, compliance to be insured and appropriate information about classification to be provided;

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.

V. Full Fairing for Main Rotor Head or the LifeRCraft demonstrator

Type of action (RIA or IA)	IA		
Programme Area	FRC – WP 2.4 Lifting Rotor [LifeRCraft]		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	400 k€	Type of agreement	Implementation Agreement
Duration of the action (in Months)	24 months (42 months including support)	Indicative Start Date[29]	Q2 2017

Identification	Title
JTI-CS2-2016-CFP04-FRC-02-18	**Full Fairing for Main Rotor Head or the LifeRCraft demonstrator**
Short description (3 lines)	
Make the detailed design and manufacture the full fairing for a main rotor head on Fast Rotorcraft. The aim is to minimize the rotor head drag. Parts will be made in composite and lightweight material to be lightweight and resistant. Investigate, test, and propose technology to ensure an innovative partial air sealing between mobile parts of the rotor head is also part of this work package.	

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

1. Background

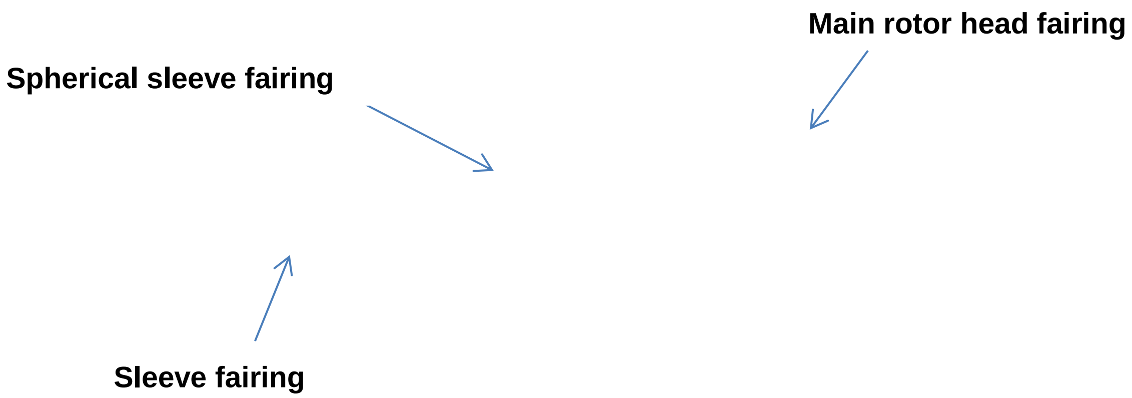
The final goal of the "Low Impact, Fast & Efficient RotorCraft (LifeRCraft)" demonstration program is to mature the compound rotorcraft configuration and pave the way for the development of future products fulfilling expectations in terms of environment protection, citizen mobility and competitiveness.

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 main rotor head has been identified as one of the first contributor to the overall aircraft drag. This optimization of drag is a key factor of the success of the coumpound formula where the cruise speed has been significantly increase compare to legacy rotorcraft. 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 detailed design and the manufacturing of the main rotor head fairings and also give the possibility to the partner to propose, design, test, and implement new concept of partial air sealing that optimized the drag reduction.

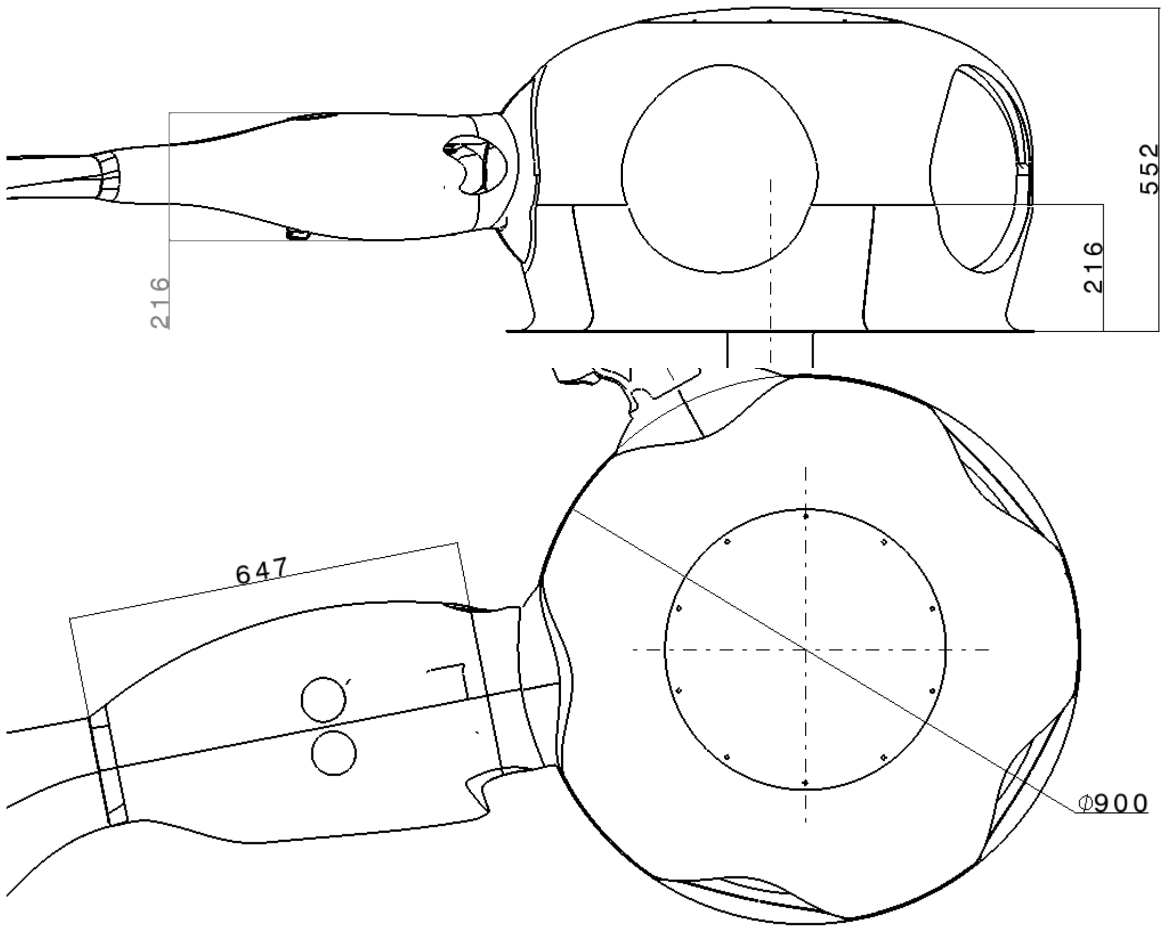
2. Scope of work

The aim of this Call for Proposals is to release the detailed design and manufacture the main elements constituting main rotor head fairing and also to propose, design, test, and implement new concept of partial air sealing mobile parts. Activities of project management, engineering, manufacturing and tests have then to be performed by the Partner.
A composite background and an technical opening on additive manufacturing would be a best.

Tasks		
Ref. No.	***Title – Description***	***Due Date***
Task 1.0	Inputs Delivery by the Topic Manager	T0
Task 1.1	Detailed Design of main rotor head fairings	T0 + 6 Months
Task 1.2	Investigate of partial air sealing between mobile parts of the fairing.	T0 + 6 Months
Task 1.3	Test of partial air sealing between mobile parts of the fairing.	T0 + 9 Months
Task 1.4	Manufacturing and quality insurance main rotor head fairing parts.	T0 + 14 Months
Task 1.5	Blank assembly of rotor head fairing	T0 + 14 Months



3D view of the main rotor head fairings



Views of the preliminary main rotor head fairings with main dimensions
These drawings and dimensions are preliminary, final information's will be available after partner selection.

<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 main rotor head fairing preliminary study (CATIA files) including support and interfaces,
- Preliminary definition and studies.
- Specification including (Structural loads and thermal conditions)

Task 1.1: Detailed Design of main rotor head fairings

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 main rotor head fairing parts. Such Design must pay peculiar attention on :

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

The design has to take into account of the high level of centrifugal forces applied to the parts.

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

- Computational Structural Mechanics (CSM) calculations to ensure compliance with specified structural loads and temperature (in the case that the partner is not able to perform those kind of activities, the leader will take this charge)

Task 1.2: Investigate of partial air sealing between mobile parts of the fairing.

As previously mentioned the rotor head has been identified as one of the first contributor to the overall drag of the rotorcraft as a consequence the fairing of this subassembly could improve significantly the figure. The fuel consumption is directly linked to the drag of the aircraft.

The rotor head is composed of mobile parts, the drag optimization go with a reduction of air that enter inside the fairing. The investigation and the definition of a partial air sealing robust to gap variation will be necessary.

Task 1.3: Test of partial air sealing between mobile parts of the fairing.

Following the previous task, I will be necessary to define a test campaign to validate the technologies identified.

This task contains all activities relative to this test campaign that could be done on simplified sub assembly.

Task 1.4: Manufacturing and quality insurance main rotor head fairing parts.

The Partner has to manufacture the main rotor fairing parts 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.

The Partner has to manufacture at least 2 sets of all the parts to ensure a spare delivery in case of degradation, and has to manufacture 2 sets of alternative design for investigation in flight of the upper part of the main rotor head fairing.

Task 1.5: Blank assembly of rotor head fairing

The partner has to perform a blank assembly before the final hardware deliveries

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
L1.1	Concept for main rotor fairing (material, structure, locking mechanism, modularity ...)	DOC	T0 + 3 Months
L1.2	Detailed design drawings	DOC	T0 + 6 Months
L1.3	Updated 3D models of the parts	CAD	T0 + 6 Months
L2.1	Concept for partial air sealing trade-off	DOC	T0 + 6 Months
L3.1	Test campaign program	DOC	T0 + 6 Months
L3.2	Test campaign report	DOC	T0 + 9 Months
L4.1	Blank assembly report	DOC	T0 + 11 Months
L4.2	Main rotor head fairing parts	HW	T0 + 14 Months
L5.1	Report about contribution to flight test	DOC	T0 + 42 Months

Milestones			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Design Review	MS	TO
M2	Critical Design Review	MS	T0 + 6 Months
M3	Test Readiness Review	MS	T0 + 6 Months
M4	Test Acceptance Review	MS	T0 + 9 Months
M5	HW delivery	MS	T0 + 14 Months

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

The Applicant shall have proven capabilities and skills in each of the specific areas of this Call, in particular:
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 Main Rotor Head Fairing. 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

- Appreciated: Design Organization Approval (DOA).
- Appreciated: Product Organization Approvals (POA).
- Mandatory: Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004)
- Appreciated: 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:

- Mandatory: CATIA V5 R21
- Preferably: VPM
- Preferably: 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.

4. Clean Sky 2 – Airframe ITD

I. Development of a Highly Instrumented, Modular Fan Module for Aerodynamic and Acoustic Wind Tunnel Testing

Type of action (RIA or IA)	RIA		
Programme Area	AIR, WP A-1.2.1		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	600 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	18 months	**Indicative Start Date**[30]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-AIR-01-20	**Development of a Highly Instrumented, Modular Fan Module for Aerodynamic and Acoustic Wind Tunnel Testing**
Short description (3 lines)	
A Fan stage representing the next generation of UHBR engines will be developed and run on a large test rig (SA^2FIR - Simulator for Aerodynamic and Acoustic Fan Integration) simulating the engine installation environment.	

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

1. Background

a) General

Clean sky 2 program goals include reduction in air transport fuel consumption as well as in the perceived noise levels. Both are strongly related to the integration of the aircraft engines into an airframe with mutual interactions. To investigate that topic a large scale fan module will be used to analyse installation effects of ultra-high by-pass ratio turbofan engines (UHBR).

The next generation of UHBR engines feature large diameters and short nacelles with Variable Area Fan Nozzles (VAFN). While the first results in close coupling of engine and Airframe, the latter will reduce the possibilities for acoustic treatment inside the engine and increase distortion effects. Both calls for an investigation of the influence of UHBR engine installation on the performance and noise. Also new solutions for acoustic treatments have to be assessed. Therefor a fan stage representing the next generation of UHBR engines will be developed to be used on a large rig capable to simulate the installed environment. Goal is to optimize engine installation as well as noise treatment of the engine components.

The topic has a strong link to other projects. By providing a common geometry these projects are the basis for the fan development but will also benefit from the experimental results gained by means of the developed fan.

A generic yet realistic fan stage geometry at scale 1 will be developed inside a Clean Sky 2 project to be the basis geometry for the development of CAA/CFD (CAA: computational aeroacoustics, CFD: computational fluid dynamics) tools aiming at the Aircraft (AC) integration of ultra-high by-pass ratio turbofan engines (UHBR). In a second step the developed tools will be used for the same geometry at rig scale. Finally a scaled down version of the fan geometry shall be run on the SA²FIR test bench (targets aerodynamics and acoustics). By that there should be a complete chain of results from scale 1 via rig scale (CAA/CFD) to experimental results at rig scale.

To accomplish that it is planned to have the Fan rotor/stator heavily instrumented. Unsteady sensors for pressure and deformation shall be included into the rotor, stator and casing. In addition a rotating shaft balance will be used in the rotor hub and a component balance to determine stator/nacelle loads. This calls for lightweight structures especially for the fan rotor to have reasonable balance accuracy.

So the aim is to develop advanced manufacturing technologies (e.g. machined CFRP rotor, hybrid Rotor) to incorporate a number of sensors in a fan rotor and stator without compromising aerodynamic performance and structural integrity.

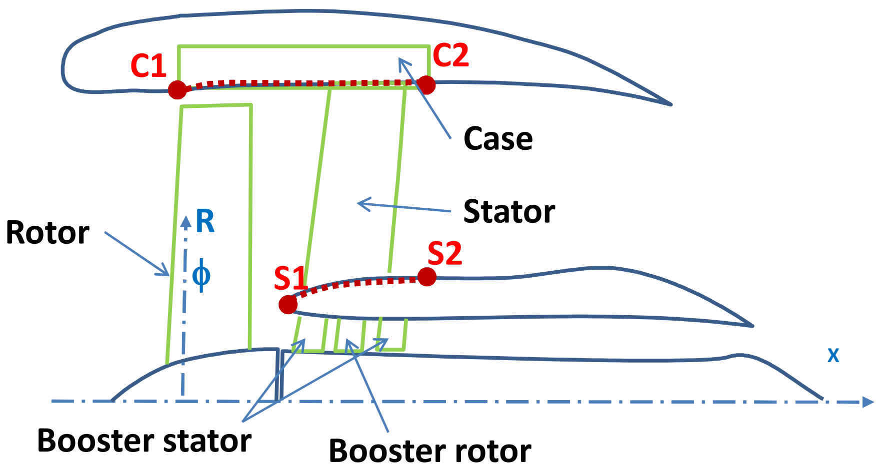
b) Fan basic parameters and dimensions

The fan module is used to simulate a UHBR engine including the core flow. Therefore the core inlet including a booster to overcome the core duct pressure losses is part of the SA²FIR rig. The fan module comprises of:

- fan rotor (by-pass and booster)
- stator (by-pass and booster)
- casing

The input power to the rotor will be in excess up to 5 MW at a speed up to 12000rpm. The module basic dimensions are described in Figure 9. Beside its aerodynamic function the stator will have to carry the nacelle loads as a structural element as well.

	C1 (Intake/fan casing interface)	C2 (Outer diameter Fan module exit)	S1 (Splitter leading edge)	S2 (Inner diameter Fan module exit)
Axial distance ΔX vs. C1 (mm)	0	330	140	330
Radius R (mm)	330	337 to 346	152	180



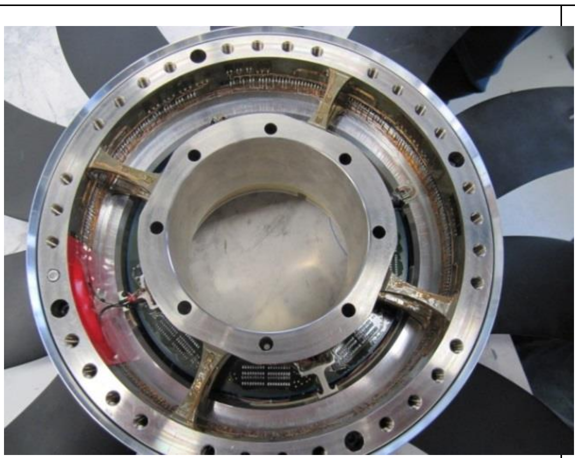
5.

6. Figure 9: Fan module basic dimensions

c) **Instrumentation**

c.1. **Fan rotor**

Fan rotor will be equipped with a rotating shaft balance (RSB), measuring the disc forces and moments. It will be installed in the hub of the rotor and connected to a telemetry system sitting on the shaft as well. An example of an RSB installed in a rotor is shown in Figure 10: RSB installed in rotor hub. The rotor blades will be equipped with flush mounted unsteady sensors for pressure mapping (see Figure 11).

7. 	8. 
9. Figure 10: RSB installed in rotor hub	10. Figure 11: flush mounted pressure sensor

d) Fan stator

The stator will sit on a component balance which is part of the SA2FIR rig. It is split in a non-instrumented load carrying part and instrumented removable vanes. As for the rotor pressure mapping sensors will be included distributed over a number of blades.

e) Fan casing

The fan casing will be used for instrumentation purposes (tip clearance, pressure rakes). It defines the outer wall of the fan module. It is also the linking part between the structural stator and the nacelle. By its design it defines the minimum allowable tip gap.

f) Booster rotor/stator

The booster rotor and stator are used to simulate the core flow and are not representative of a real engine booster (e.g. in terms of pressure ratio). Therefore instrumentation is not used on the rotor and stator but in the core duct behind to adjust and monitor core flow representation (e.g. core mass flow).

2. Scope of work

a) Requirements and design

As described in a) the input to this task is the hot shape geometry and the performance parameters associated with the operation envelope. Part of the CFP is to assess the requirements in terms of geometry, mechanical integrity and instrumentation and the derivation of a manufacturing process for the design. For the rotor the shape transformation from the hot shape (input) to a cold shape as manufactured has to be included. This transformation is strongly related to the manufacturing process and the final design of the rotor. There is no preference regarding the design approach (Bladed disk, separate blades in hub etc.). In terms of material the rig baseline assumption is a CFRP fan rotor at the moment. Validation of integrity and dynamic behaviour (mode shapes and natural frequencies including speed effect for the rotor) is part of the CfP. In terms of the rotor itself the design has to ensure that there are no dynamic issues inside the operational range (e.g. Blade flutter). In addition mass and mass moment of inertia has to be compliant with the rig needs with respect to dynamic behaviour. Also the mass properties have a strong influence on the measurement accuracy of the

rotating shaft balance. A heavy rotor requires a stiff balance and results in a low signal to noise ratio. All that calls for a lightweight design.
To a lesser extent that is true for the Stator and fan casing as well. Since both parts are connected to a component balance low weight/high stiffness is essential to gain high measurement accuracy while maintaining good dynamic behaviour and limited deflections under (dynamic) load. Especially the latter has a direct impact on performance as it drives the required tip gap for the rotor.
Beside its aerodynamic function the stator will be used as a structural element to carry the nacelle loads. A number of blades of the stator will be interchangeable allowing for a modular approach regarding the instrumentation.
Included in the design are all interfaces to surrounding Components (e.g. RSB interface)

b) <u>Instrumentation</u>

All sensors needed for the instrumentation have to be purchased by the applicant. Integration of the sensors into the components is part of the design process and the manufacturing of the parts.

Fan rotor
60 sensors will be distributed over approx. 4 rotor blades. The design has to deal with sensor integration and cable routing under extreme centrifugal loads (≈24000g at blade mid span). Specification of the location and the connection to the telemetry will be provided as an Input.
For deformation measurement and monitoring purposes strain gauges have to be included in 2 blades.

Fan stator
As for the rotor the stator includes a number of flush mounted sensors which are part of design and manufacturing To allow for certain modularity in terms of instrumentation the instrumented blades have to be removable form the stator. By that, blade sensors can be calibrated and blades with different instrumentation (e.g. with integrated hot wire traverse -- not part of this CFP) can be used instead.

Fan casing
For tip clearance measurements the casing will be equipped with capacitive sensors. The fan casing is instrumented with 8 unsteady pressure transducers at a position in between rotor and stator. The positions and interfaces are an input to the task and will be provided. Also total pressure rakes and hot wire measurements will be carried out between rotor and stator and behind the stator. The rakes and traversing mechanisms are not part of this CFP but the physical access and interfaces have to be incorporated following a respective specification.

c) <u>Manufacturing</u>

Al parts have to be manufactured with high accuracy in shape (within ±0.07mm) and with high surface quality (Rz = 0.4) to assure that the performance is representative at the reduced scale.
Parts to be manufactured:

- Fan rotor (hub and blades including interfaces to the shaft)
- Booster rotor
- Fan stator (structural load carrying)
- Booster stator
- Instrumented interchangeable stator vanes
- Fan casing

Integration of instrumentation is part of the design and manufacturing process. It includes the physical sensor integration, cable routing and interfaces as well as function checks and calibration of the instrumentation.

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T1	Analysis of requirements and choice of manufacturing technology	T_0+3 months
T2	Predesign including instrumentation needs	T_0+6 months
T2	Final design incl. validation of integrity, dynamic behaviour, instrumentation	T_0+9 months
T3	Parts Manufacturing	T_0+14months
T4	Integration of instrumentation	T_0+17 months
T5	Rig integration	T_0+18 months

3. Major deliverables/ Milestones and schedule (estimate)

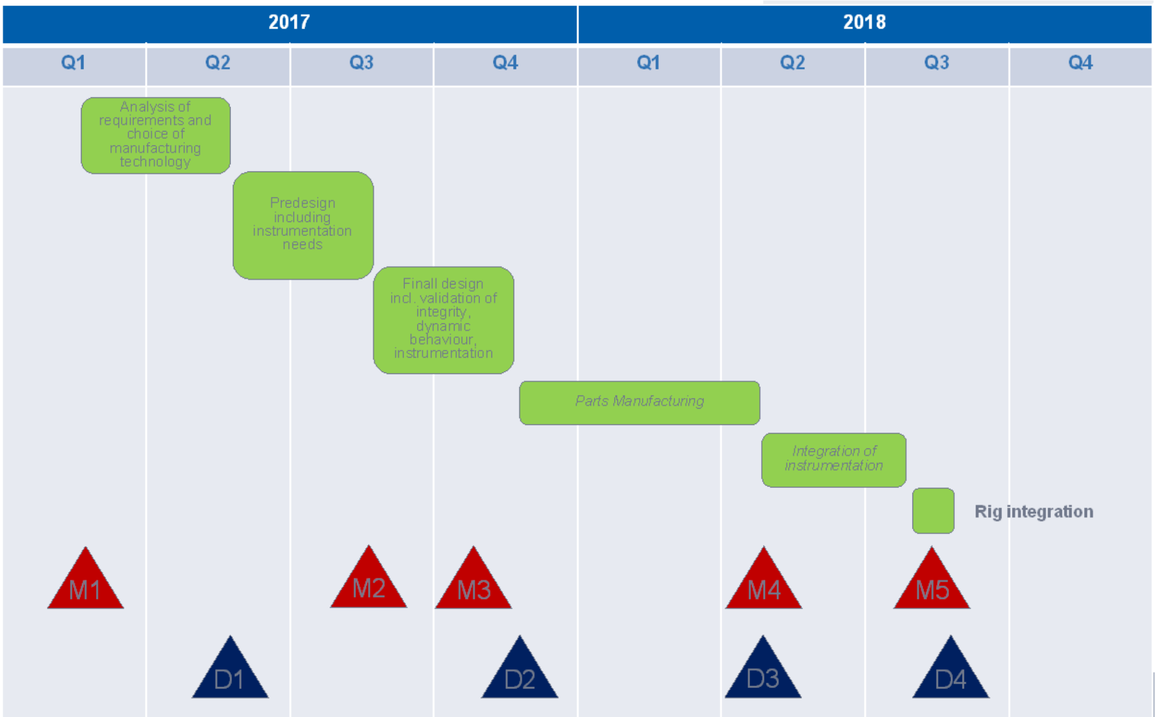
Deliverables			
Ref. No.	***Title – Description***	***Type (*)***	***Due Date***
D1	Choice of manuf. Technology, concept for integration of instrumentation	RM	T_0+3 months
D2	Mechanical design	R and RM	T_0+9 months
D3	Fan/Stator hardware incl. Instrumentation	D	T_0+14 months
D4	Fan module integration	D	T_0+18 months

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

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M1	Kick off Meeting, Specification ready	RM	T_0+0months
M2	Preliminary design review	RM	T_0+6months
M3	Critical design review	R and RM	T_0+8 months
M4	Parts delivery	D	T_0+14 months
M5	General acceptance - TRR	RM	T_0+18 months

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

Schedule for Topic Project:



4. Special skills, Capabilities, Certification expected from the Applicant

The applicant(s) should have expertise in:

- Advanced manufacturing technologies for rotating machinery (propellers turbo-machines etc.)
- the integration of miniaturized sensors in rotating/non rotating highly loaded structures
- FEM (isotropic/anisotropic materials)
- Wind tunnel instrumentation

II. Integrated Automated Test Bench Control System with Certifiable Test Documentation Functionality

Type of action (RIA or IA)	IA		
Programme Area	AIR - WP A 1.4.6 Virtual Modelling for Certification		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	600 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	18 months	**Indicative Start Date**[31]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-AIR-01-21	**Integrated Automated Test Bench Control System with Certifiable Test Documentation Functionality**
Short description (3 lines)	
A reliable and reproducible operation of test facilities for aviation purposes is mandatory. In order to improve the quality and the degree of automatisation of the Clean Sky Ground Thermal Test Bench and demonstrators a standardized platform of controller hardware and software shall be introduced. Less complexity would increase the quality and reliability of the test facilities and ease the introduction of automated test sequences. The better adaptability is needed for a flexible optimisation of control algorithms.	

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

1. Background

The control and measurement system of the Clean Sky Ground Thermal Test Bench and the Flight Test facility is distributed on several measurement and control systems which do not yet provide full access to the control algorithms of the test facilities. The fusion of pure measuring devices with a flexible control system would allow to improve the control algorithms and the at least partly automatization of the test procedures. This would also reduce the operators influence on test performance and increase the level of reproducibility and reliability. Today very detailed knowledge of the operators is mandatory to achieve precise environmental conditions in an optimal time frame; this intelligence could then be implemented directly in the control system. Furthermore safety issues could be directly applied in the control system and an automated control system logging system could be implemented for enhanced test documentation. There is a significant potential for improvement of bench performance, when the control competences of Topic Manager could be fully applied on the control systems. Thus, it is required that the control system is based upon an open source approach assuring full code access and modification possibility of the control system by Topic Manager staff. The automatic generation of test procedures and reports is very favourable.

2. Scope of work

The work is separated into 4 different phases: The requirement alignment, the design phase followed by the production phase and finally the testing and qualification of the system. The final result shall be a Beckhoff compatible HW-demonstrator connected to the test facilities, provided with a control SW, which provides protocol based testing with automatic test procedure and test report export.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
1	Requirement alignment	T0+3M
1 a	Definition and harmonization of detailed requirements, based on Topic Manager preliminary requirements	T0+2M
1 b	Definition of interfaces to the existing Topic Manager thermal test facilities	T0+3M
2	System Design	T0+9M
2 a	Preliminary design (PDR)	T0+6M
2 b	Detailed Design (CDR)	T0+9M
3	System Production	T0+12M
3 a	Manufacturing and Installation of demonstrator Control HW	T0+12M
3 b	Development of new SW for operators and control experts	T0+12M
4	Verification of Test Bench Control & Automation demonstration system	T0+15M
5	Closure of remaining actions	T0+18M

Task 1 Requirement Alignment

1a Definition and harmonization of detailed requirements

Analysis of detailed requirements for the Test Bench Control & Automation with Topic Manager will be performed. The existing HW and the SW have to be reviewed to assure that the required HW interfaces can be integrated and that the SW provides the necessary features to assure the functionality of the system considering the requirements specified. Characteristics of the existing HW and SW will be provided by the Topic Manager at the beginning of the project.

1b Definition of interfaces to the existing test facilities

Upon review of the existing control and measuring system components, an analysis of specific interfaces to be connected to the new control system is required. Additionally, the applicant must assure that adequate control components will be available for each specific interface.

Task 2 System Design

2a Preliminary Design

HW: Definition of the components that are required on the demonstrator system.
SW: Provision of first description of SW architecture able to comply with the required functionality and of the necessary GUI (Graphical User Interface) for control expert and for operator.
This phase will be concluded by the PDR.

2b Detailed Design

Based on the Preliminary Design, the detailed system design including the complete wiring diagrams shall be prepared. For the SW, the open points and actions from the PDR shall be integrated.
This phase is closed with the closure of the CDR actions.

Task 3 System production

3a Installation of demonstrator Control HW

Manufacturing of controller rigs and integration into the test facility infrastructure shall be performed. The documentation for the installed HW shall be provided.

3b Development/Adaptation of SW for operators and control experts

Develop and/or adapt the SW according to the definition of the CDR. Create a user manual, which shall be used during the testing phase. Install the SW on the computers of the Topic Manager Test facilities.

Task 4 Verification of Test Bench Control & Automation demonstration system

The activities shall include:

1. Define a validation matrix for all requirements.
2. Establish an Acceptance Test in cooperation with Topic Manager that covers the requirements that

need a test for validation.

3. Train the operators and control experts of Topic Manager on the demonstrator system.

This phase is closed with the successful performance of the ATP (Acceptance Test Procedure) and the closure of the actions which arose during the validation phase.

Task 5 Closure of remaining actions

If applicable, close the remaining actions from Task 4.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D1	Requirement and Interface Specification	D	T0+3M
D2	Requirement Review	R	T0+3M
D3	Preliminary HW and SW description	D	T0+5M
D4	Preliminary Design Review	R	T0+6M
D5	Detailed HW and SW description	D	T0+8M
D6	Critical Design Review	R	T0+9M
D7	Documentation of installed HW for the demonstrator system	D	T0+12M
D8	HW of the Demonstrator System	H	T0+12M
D9	User manual for the SW/HW	D	T0+12M
D10	Acceptance Test Procedure for the Demonstrator System	D	T0+13M
D11	SW release for ATP of the Test Bench Control & Automation System	S	T0+15M
D12	Test Readiness Review	R	T0+15M
D13	Acceptance Test Report for the Demonstrator System	D	T0+16M
D14	Delivery of final HW / SW and documentation	H / S	T0+18M

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Requirements Review	R	T0+3M
M2	PDR	R	T0+6M
M3	CDR	R	T0+9M
M4	Prototype ready for testing	R	T0+12M

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M5	Test readiness review passed	R	T0+15M
M6	Remaining Actions closed	R	T0+18M

<u>Gantt Chart for deliverables and Milestones</u>

		Month																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
D1	Requirement and Interface Specification			■															
D2	Requirement Review			M1															
D3	Preliminary HW and SW description					■													
D4	Preliminary Design Review						M2												
D5	Detailed HW and SW description								■										
D6	Critical Design Review									M3									
D7	Documentation of installed HW for the demonstrator system												■						
D8	HW of the Demonstrator System												■						
D9	User manual for the SW/HW												M4						
D10	Acceptance Test Procedure for the Demonstrator System													■					
D11	SW release for ATP of the Test Bench Control & Automation System															■			
D12	Test Readiness Review															M5			
D13	Acceptance Test Report for the Demonstrator System																■		
D14	Delivery of final HW / SW and documentation																		M6

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

- Excellent knowledge of control and measuring systems
- Excellent knowledge of high performance electrical systems
- Excellent knowledge of test automatization and documentation
- Excellent knowledge of SW development process
- Certified for EN 50110-1;-2

III. Laminated and panoramic Cabin Windows for Business Jet applications

Type of action (RIA or IA)	IA		
Programme Area	AIR - WP A-3.2 High Performance & Energy Efficiency		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	400 k€	Type of agreement	Implementation Agreement
Duration of the action (in Months)	24 months	Indicative Start Date[32]	Q2 2017

Identification	Title
JTI-CS2-2016-CFP04-AIR-01-22	Laminated and panoramic Cabin Windows for Business Jet applications
Short description (3 lines)	
The objectives of the project are twofold: firstly, development of a laminated Cabin Window (CW), and secondly, analysis of the implementation of a panoramic laminated CW. Two demonstrators are to be manufactured in the frame of this project: • A first one integrating a laminated cabin window (on the basis of typical business jet Cabin Window) keeping the current installation principles i.e. « plugged design » • A second one integrating a panoramic laminated CW, for which design principles will have to be defined (resp.: Partner), as well as installation principles (joined responsibility Topic Manager/Partner)	

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

1. Background

Acoustic, lightness of the cabin, as well as passengers comfort, are the major contributors to business jets cabin interior competitiveness. On the other hand, cabin windows (CW) are an important contributor to cabin noise (due to the air flow turbulences).

Today, the reference cabin window is made up of two acrylic panes with a film of air in between. Each window is fitted with a « window shade box », containing the window obscuration system. This box is closed by a third clear, non structural panel (inner window - “dust cover”). A cover panel then encases the window – window shade assembly.

The « two panes + air film » solution is not optimum from a weight saving perspective. Laminated cabin windows can potentially replace current solution with improvement of weight and acoustic. The technology consists in two acrylic (or equivalent transparent material) panes laminated together with clear, organic films in between.

Therefore, this project aims at improving performance and comfort of business jets cabin windows by working on two linked subjects:

- First the development of a laminated business jet cabin window, in order to save weight (and potentially decrease directly or indirectly acoustic noise),
- Then the development of a panoramic laminated cabin window in order to improve passenger’s comfort and travel experience.

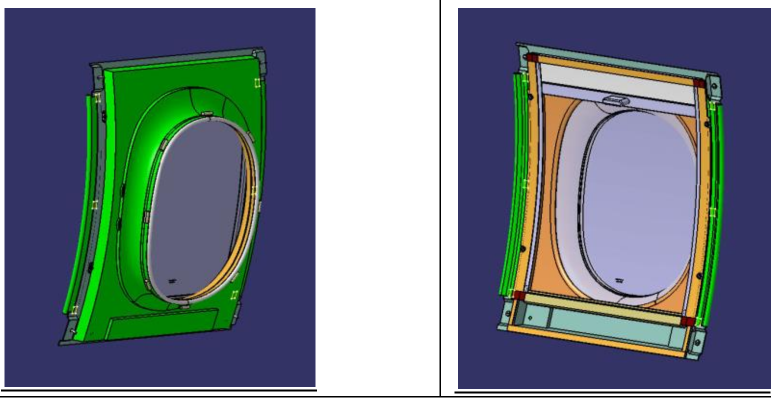


Figure 12 : curtain box + window area

2. Scope of work

1) Generalities

The objectives are twofold:

1. WP1: Improvement of CW performance keeping the same window surface as reference aircraft.
2. WP2 : Development of a panoramic CW in order to study its implementation in a business jet fuselage, and characterize acoustic of the window.

Example of a panoramic cabin window in a business jet

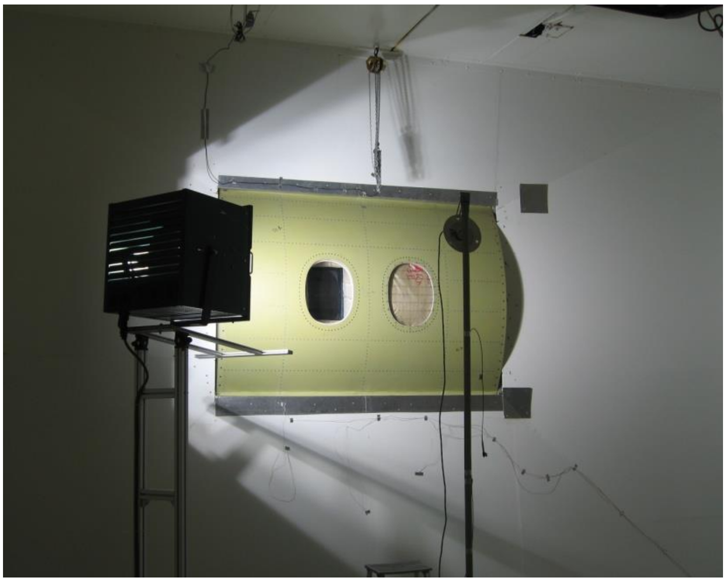
Two demonstrators are to be manufactured in the frame of this project:

- A first one integrating a laminated cabin window keeping the current installation principles i.e. « plugged design »
- A second one integrating a panoramic laminated CW, for which design principles will have to be defined (resp.: Partner), as well as installation principles (joined responsibility Topic Manager/Partner)

The first demonstrator is a fuselage section (scale 1) with 2 laminated CWs. The fuselage panel will be provided by the Topic manager.

The second demonstrator is a fuselage section (scale 1) with 1 panoramic laminated cabin window. The fuselage panel will be provided by the Topic Manager. For the 2nd demonstrator, demonstrations/analysis will also be undertaken to validate the window size increase: design studies (e.g. distance between fuselage frames), mechanical sizing, weight etc.

For both demonstrators, weight and acoustic are the key design drivers.



Example of a fuselage panel being tested for light transmission in the acoustic chambers (same installation is used for acoustic tests)

2) Tasks description

WP1 Laminated cabin window

WP1 Laminated cabin window		
Ref. No.	***Title – Description***	***Due Date***
Task 1.1	Preliminary design of the laminated cabin window and associated ICDs (based on the cabin window specification given by the Topic Manager at T0 + 2 months)	T0 + 6 months
Task 1.2	Consolidated design of the laminated cabin window	T0 + 9 months
Task 1.3	Demonstrator parts manufacturing	T0 + 15 months
Task 1.4 (TM responsibility + support of the partner)	Demonstrator assembly with possible support of the partner	T0 + 16 months
Task 1.5	Certification tests of the cabin window (pressure, environment, etc.)	T0 + 18 months
Task 1.6	Report on the laminated cabin window design, manufacturing and associated qualification tests	T0 + 20 months
For information : Topic Manager final evaluations		
For information (TM responsibility)	Acoustic transmission tests of the demonstrator	(T0 + 20 months)
For information (TM responsibility)	Assessment on assembly and testing of the demonstrator	(T0 + 24 months)

WP2 Panoramic cabin window

WP2 Panoramic cabin window		
Ref. No.	***Title – Description***	***Due Date***
Task 2.1	Preliminary design of the panoramic cabin window and associated ICDs (based on the cabin window specification given by the Topic Manager at T0 + 6 months)	T0 + 10 months
Task 2.2	Consolidated design of the panoramic cabin window	T0 + 13 months
Task 2.3	Demonstrator parts manufacturing	T0 + 19 months
Task 2.4 (TM responsibility + support of the partner)	Demonstrator assembly with possible support of the partner	T0 + 20 months
Task 2.5	Certification tests of the cabin window (pressure, environment, etc.)	T0 + 23 months
Task 2.6	Report on the panoramic cabin window design, manufacturing and certification	T0 + 24 months
For information : Topic Manager final evaluations		
For information (TM responsibility)	Acoustic test of the demonstrator	(T0 + 22 months)
For information (TM responsibility)	Assessment on assembly and testing of the demonstrator	(T0 + 24 months)

General remarks:

- The architecture of the transparents will be done in close cooperation with the Topic Manager teams in charge of the fuselage design.
- The development of the transparents (shape, dimensions, interface, materials selection, etc.) has to be done in cooperation with the Topic Manager.

3. Major deliverables/ Milestones and schedule (estimate)

WP1 Deliverables – Laminated cabin window			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 1.1	Preliminary design of the laminated cabin window and associated ICDs	R	T0 + 6 months
D 1.2	Consolidated design of the laminated cabin window	R	T0 + 9 months
D 1.3	Demonstrator parts manufacturing	H	T0 + 15 months
D 1.5	Report on the laminated cabin window design, manufacturing and certification	R	T0 + 20 months
For information : inputs under Topic Manager responsibility			

WP1 Deliverables – Laminated cabin window			
D 1.0 (TM responsibility)	Specification of the cabin window and associated certification tests	R	T0 + 2 months
D 1.4 (TM responsibility with partner support)	Demonstrator assembly with possible support of the partner	H	T0 + 16 months

WP2 Deliverables – Panoramic cabin window			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 2.1	Preliminary design of the laminated panoramic cabin window and associated ICDs	R	T0 + 10 months
D 2.2	Consolidated design of the panoramic laminated cabin window	R	T0 + 13 months
D 2.3	Demonstrator parts manufacturing	H	T0 + 19 months
D 2.5	Report on the panoramic laminated cabin window design, manufacturing and certification	R	T0 + 24 months
For information : inputs under Topic Manager responsibility			
D 2.0 (TM responsibility)	Specification of the panoramic cabin window and associated certification tests	R	T0 + 8 months
D 2.4 (TM responsibility with partner support)	Demonstrator assembly with possible support of the partner	H	T0 + 20 months

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

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

- Providing material data which are required to achieve "permit to fly",
- Using materials, process, 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 actively with the Topic Manager at any state of work,
- Giving access to the production and tests sites,
- Performing updates of documentation in case of insufficient documentation for authorities,

The applicant must be capable of providing data inputs for Life Cycle Analysis (LCA) to define environmental impact of technologies (energies, volatile organic compounds, waste, etc.) for important design and manufacturing milestones.

The applicant must be capable of monitoring or decreasing the use of hazardous substances regarding REACH regulation.

Special skills :

- Aerospace transparencies development, optimization, testing experiences on certified programs.

- Capability of mechanical testing of cabin window certification tests.

- Necessity to be capable of the industrialization of the transparents in serial parts, whether at the applicant production site or to another company.

IV. Novel manufacture of low weight skin without chemical milling

Type of action (RIA or IA)	RIA		
Programme Area	AIR - WP A-3.3 Innovative shapes & structure		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	900 k€	Type of agreement	Implementation Agreement
Duration of the action (in Months)	30 months	Indicative Start Date[33]	Q2 2017

Identification	Title
JTI-CS2-2016-CFP04-AIR-01-23	Novel manufacture of low weight skin without chemical milling
Short description (3 lines)	
The manufacture of door skins and panels with double curvature and low weight is traditionally done by stretch forming and chemical milling (etching) of sheets. The objective of this research topic is to develop production methods that do not require chemical milling. The objective is to reduce the environmental impact of manufacture (remove chemical etching), shorten lead-times for production and reduce production costs.	

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

1. Background

This topic is part of Airframe High Performance and Energy Efficiency (Activity Line A) 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. Manufacture of skins with double curvature is traditionally done by stretch forming and chemical milling (etching) of sheets. This production method results in high costs for tooling, long lead times and a negative environmental impact.

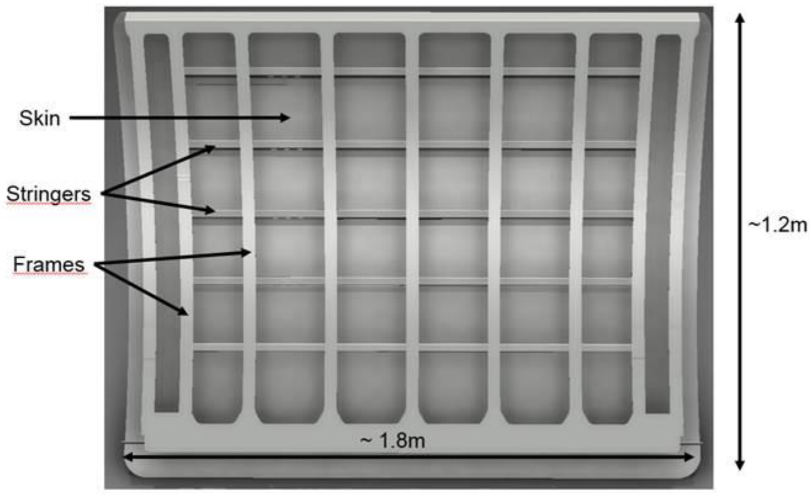
New Aluminium alloys and production methods have arisen over the last few years enabling a development of traditional aircraft skin manufacture methods (etching). In addition some of the new methods allow a much higher degree of part integration in the skin, permitting a more complex integrated structure. This topic contains three different manufacture concepts for an aircraft cargo door skin. The three concepts differ slightly (in terms of how much structure is integrated into the skin) to match the intended manufacture process whilst ensuring that the design meets the requirements for a cargo door skin.

Manufacture concept 1: Stretch forming of a double curved skin with varied thickness. The objective for this concept is to form a traditionally thin walled skin, but instead of chemical milling, the areas traditionally etched will be machined before forming, when the sheet is in a flat condition. This skin has no integrated structure.

Manufacture concept 2: This concept revolves around a relatively new material (AlMgSc). In this concept traditionally etched areas will be machined and the stringers will be integrated by either friction stir welding or laser welding, when the sheet is in flat condition. Vacuum tooling and heat treatment will enable the forming of the skin + stringers to take place.

Manufacture concept 3: This concept involves machining a doubly curved skin with complex integrated structure, all from the same billet. To reduce the amount of raw material and the time for machining, a preformed billet shall be used; this billet shall have a near shape to the part to be manufactured.

This document describes activities, an 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.



A typical structural configuration and size for an aircraft cargo door.

(Note that the internal structure is not representative of the skins to be designed and manufactured in this topic however it shows a typical configuration of the skin, frames and stringers)

2. Scope of work

The work packages for this call will result in the manufacture of three different demonstrators for cargo doors skins of varying complexity, all manufactured with aerospace grade aluminium alloys (to be agreed with the topic manager). The initial studies of all three work packages is to be conducted with support and guidance from the topic manager and will identify the preferred design for each manufacture concept. The objective with all three concepts is to replace the chemical etching and to reduce the manufacturing cost compared to traditionally etched skins and riveted/fastened frames. The weight of the door skin is obviously of high importance and weight shall be as low as possible, the skin target weight will be defined by the topic manager and will depend on the agreed concept.

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

Work Packages		
Ref. No.	***Title – Description***	***Due Date***
WP 1	Development of a manufacturing method for a stretch formed door skin with varied thicknesses	T0+30
WP 2	Development of a manufacturing method for a vacuum formed door skin with integrated stringers that are welded	T0+30
WP 3	Development of a manufacturing method for a door skin with integrated structure machined from a preformed billet	T0+30

WP1 – Development of a manufacturing method for a stretch formed door skin with varied thicknesses

Stretch forming is a well-known production method, but today it involves forming a plane sheet without any thickness variations. In order to reduce the weight of a typical aircraft skin structure, material is removed by chemical milling (etching) after the forming operation.

The objective of WP 1 is to find methods and tooling concepts that enable the forming of flat sheets which have been pre-machined, providing areas of varied thickness (in a similar way to which etching is typically used after forming).

An investigation into the stretch forming of aluminium alloys sheets with variable thickness is to be performed in order to study the properties of the material, it is important that the effects from heat treatment are taken into account. A study of different tool concepts needs to be conducted however one suggestion is that the tooling can consist of a disposable insert applied in the area to be machined, or as a part of the forming tool. The forming tool is to be designed and manufactured according to a concept which will be discussed and approved by the topic manager; a skin containing machined areas shall then be formed. The manufactured skins shall be verified both regarding material properties and geometrical result; 2 skins shall be delivered to the topic manager for further investigations.

Thus, WP 1 shall identify an appropriate tooling concept for the described production method, manufacture a skin and analyse effects of the material properties as well as the geometrical result.

Initial pre-study reports of possible tooling concepts and their effect on material properties are two important deliverables of the WP. These two reports are required before start of tool manufacture. Preliminary results are set to be delivered halfway through the project timeline and close collaboration with the topic manager will be required in order to make suitable decisions and necessary changes.

WP 2 – Development of a manufacturing method for a vacuum formed door skin with integrated stringers that are welded

In **WP2** a newly developed aluminium alloy (AA5028, AlMgSc) will be investigated and therefore a study of material properties will be executed. The skin panel will be manufactured of sheet metal and machined in flat condition with variable thicknesses. After machining, stringers will be welded on the skin panel by friction stir or laser welding. In the last manufacture state the forming will take place, the skin panel will be mounted on a vacuum tool and heat treated to final shape. The final skin is to be verified regarding both material properties and geometrical result.

WP 2 shall identify an appropriate tool concept for the described production method, manufacture a skin panel and analyse effects on the material properties as well as the geometrical result. Pre-study reports of possible tooling concepts and the effect on material properties are two important aspects of the WP. The two reports are required before start of tool manufacturing.

2 skin panels shall be delivered to the Topic Manager.

WP 3 – Development of a manufacturing method for a door skin with integrated structure machined from a preformed billet

WP3 will focus on a machined part with integrated structure. The objective is to optimise the design of the door so that it can be machined from a single curvature preformed plate, integrating as much of the inner door structure as possible and enabling a variable thickness one-piece part.

Today a part with double curvature is typically machined from a flat plate and the tooling is therefore also designed to hold a flat plate. The thickness of a typical plate can in many cases be greater than 75 mm but the thickness of the actual part is less than 25 mm due to the curved nature of the part. This results in a great waste of material and machining time as most of the material is machined away. If the plate (billet) has a near shape to the final part, a significant cost reduction and environmental/waste benefit can be achieved.

Due to the single curvature shape of the billet the properties of the material need to be investigated and new tooling concepts need to be developed. Stress free clamping of the curved billet in the fixture needs to be ensured, this stress free clamping also needs to be ensured after the deformation of the part resulting from initial roughing and stress release. The tooling must be designed in a way so that it can account for the manufacturing tolerances of the pre formed billet and the resulting deformation of the roughed part/billet. After final machining the part is to be verified both regarding material properties and the geometrical result.

2 skin panels shall be delivered to the Topic manager.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 1.1	Pre study of material properties	Report	T0+9
D 1.2	Pre-study of Tool concept	Report	T0+9
D 1.3	Demonstrator manufactured	Demo	T0+24
D 1.4	Verification of geometrical result and material properties	Report	T0+30
D 1.5	Cost breakdown	Report	T0+30
D 1.6	Delivery of 2 skins to Topic Manager	Physical delivery	T0+30
Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M 1.1	End user requirements	Report	T0+3
M 1.2	Pre-studies	Report	T0+9
M 1.3	Tooling design frozen	CAD Model	T0+12
M 1.4	Tool manufactured	Physical	T0+20

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 2.1	Pre study of material properties	Report	T0+9
D 2.2	Pre-study of Tool concept	Report	T0+9
D 2.3	Demonstrator manufactured	Demo	T0+24
D 2.4	Verification of geometrical result and material properties	Report	T0+30
D 2.5	Delivery of 2 skins to Topic Manager	Physical delivery	T0+30
Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M 2.1	End user requirements	Report	T0+3
M 2.2	Pre-studies	Report	T0+8
M 2.3	Tooling design frozen	CAD Model	T0+12
M 2.4	Tool manufactured	Physical	T0+20

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 3.1	Pre study of material properties	Report	T0+06
D 3.2	Pre-study of Tool concept	Report	T0+06
D 3.3	Demonstrator manufactured	Demo	T0+24
D 3.4	Verification of geometrical result and material properties	Report	T0+30
D 3.5	Delivery of 2 skins to Topic Manager	Physical delivery	T0+30

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M 3.1	End user requirements	Report	T0+3
M 3.2	Pre-studies	Report	T0+9
M 3.3	Tooling design frozen	CAD Model	T0+12
M 3.4	Tooling manufactured	Physical	T0+20

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 skin stretch forming (aluminium).
- Experience in technological research and development for innovative products and processes.
- Experience with aircraft part design and tooling design
- Detailed knowledge and understanding of the mechanics behind skin forming and the ability to simulate this process
- Experience of working with suppliers of aluminium billets and plates
- Knowledge and experience of friction stir welding and/or laser welding of aircraft parts
- Experience in deformation and damage mechanisms of metallic materials and structural strength modelling

Capabilities and/or access to:

- CATIA CAD software, V5 R24 or later.
- Vacuum forming of skin
- Machining of aluminium
- Forming of aluminium billets
- Suitable simulation software
- Friction stir welding/laser welding

- Suitable manufacture and machining facilities
- Suitable prototype workshop
- Mechanical testing facilities and residual stress measurement facilities
- Heat treatment facilities

V. Multi-Functional Cabin Rest Area

Type of action (RIA or IA)	IA		
Programme Area	AIR – WP A-5.1.1		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	500 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	30 months	**Indicative Start Date**[34]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-AIR-01-24	**Multi-functional cabin rest area**
Short description (3 lines)	
A multi-functional cabin crew rest area, providing improved thermal, acoustical and private comfort, shall be specified, prototypically implemented and evaluated. The area shall allow, besides crew rest, medical treatment of passengers and satisfaction of specific cultural needs (e.g. prayer area).	

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

1. Background

Drivers for enhanced aircraft efficiency are fuel-efficient engines, improved aerodynamics and optimized usage of cabin space. One option to make best use of cabin space are optimized galleys with reduced working space and rest room for the cabin crew. As compensation, other space may be utilised for cabin crew rest, provided that adequate comfort (in particular regarding thermal and acoustic aspects) can be provided. The space may then also be used for medical treatments in case of inflight incidents or for other purposes. As an example, areas immediately adjacent to aircraft doors that are commonly unused during the flight may be considered. Other options may result from multi-deck utilisation concepts.

The scope of this Topic is therefore to develop and validate a concept that allows efficient use of cabin space in a multi-functional way. One objective is to provide space and functionality to facilitate cabin crew rest during specific phases of the flight. This will help to overcome fatigue issues resulting from service operations in a tight working environment. Other use cases are to fulfill the needs of specific user groups. For example, a prayer area could be provided that meets the requirements of passengers with different cultural background. And in case of an in-flight medical incident the area may be used for medical treatment of passengers or crew. The overall goal is to provide a multi-functional area that allows versatile usage with functions that are integrated in such a way that a quick conversion, in particular in case of in-flight incidents, is facilitated.

2. Scope of work

Task T-1: In a first step, operational and functional requirements and constraints shall be identified and validated. For this the needs of specific user groups and of passengers with different cultural background shall be considered.

Task T-2: A concept for a multi-functional cabin crew rest area shall be developed. The concept shall describe in detail the layout of the versatile crew rest area, its integration in the cabin environment and how the intended functions shall be implemented. Architectural aspects shall be considered to avoid operational conflicts with other cabin functions and areas (e.g. lavatories, galleys). Required modifications of surrounding areas and installed items shall be analysed in detail. Specific attention shall be paid to environmental aspects like temperature and noise to ensure adequate comfort for a rest area.

Task T-3: A three-dimensional CAD model of the versatile crew rest area shall be built to allow a first validation of the concept.

Task T-4: The concept shall be implemented as a physical mock-up on a scale of 1:1. This mock-up shall be suitable to demonstrate the full scope of the defined functions and to validate the concept through tests involving representative test persons including professional cabin crew.

Task T-5: The mock-up shall be integrated in a representative cabin environment. The integration shall be concluded by functional tests.

Task T-6: Operational evaluations shall be performed, where cabin crew shall execute representative tasks and activities and, subsequently, assess the area and the provided functions regarding comfort, functionality and usability. A description of the test set-up, the scenarios developed for testing, the test execution and the test results shall be comprised in a concluding report.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T-1	Identification of operational and functional requirements	T0 + 3
T-2	Definition of a concept for a multi-functional cabin crew rest area	T0 + 9
T-3	Development of a 3D CAD model of the rest area	T0 + 12
T-4	Building, function testing and delivery of a physical demonstrator	T0 + 20
T-5	Integration of demonstrator in representative cabin environment	T0 + 24
T-6	Conduction of operational tests involving test persons	T0 + 30

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D-1	Functional and operational requirements	Document	T0 + 3
D-2	Concept description	Document	T0 + 9
D-3	3D CAD model (e.g. CATIA)	File	T0 + 12
D-4	Physical demonstrator	Mock-up	T0 + 20
D-5	Integrated test environment	Mock-up	T0 + 24
D-6	Evaluation report	Document	T0 + 30

Milestones		
Ref. No.	***Title – Description***	***Due Date***
M-1	Concept defined and described in detail	T0 + 9
M-2	Physical demonstrator available	T0 + 20
M-3	Test environment available and function tests performed	T0 + 24
M-4	Evaluation results available	T0 + 30

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

- The applicant shall have profound knowledge of aircraft cabin operations and related regulations.
- The applicant shall have knowledge of aircraft certification requirements.
- The applicant shall have knowledge of ergonomics and occupational safety.

- The applicant shall provide industrial capability for manufacturing physical mock-ups.
- The applicant shall provide adequate information necessary for an effective and efficient project management during the course of the project.

VI. Development of methods for deriving optimized shapes of morphing structures considering both aerodynamic performances and specific mechanical morphing boundary conditions

Type of action (RIA or IA)	RIA		
Programme Area	AIR - WP B-1.4.2		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	350 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	25 months	**Indicative Start Date**[35]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-AIR-02-28	**Development of methods for deriving optimized shapes of morphing structures considering both aerodynamic performances and specific mechanical morphing boundary conditions**
Short description (3 lines)	
Target shapes for deflected positions of morphing structures shall be computationally derived. They have to be optimized regarding drag and lift properties and also mechanically feasible considering material strain. This is an important morphing specific boundary condition, which is linked both to the base shape and the deformed shape. Additionally, mechanical complexity should be taken into consideration, e. g. a smooth strain distribution or the required local radii modifications during morphing.	

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

1. Background

Morphing structures are a promising solution for noise and drag reduction in future aircraft. They are intended to replace or supplement current aircraft high lift devices which today typically have the disadvantage of gaps in deployed position. These gaps are unintendedly sources of noise radiation and aerodynamic drag. Morphing structures replace these devices by a gapless solution based on skin deformation of the wing. In WP B-1.4 of the Airframe ITD a morphing leading edge replacing conventional leading edge high lift devices, like for instance slats, will be under investigation. For the design of a morphing structure it is important to define the desired shape, keeping in mind material limitations, which represent a limitation for the possible shapes that the morphing structure can assume

2. Scope of work

The tasks comprise method development for integration of drag, lift and material limitations concerning its morphing capability in one optimization process and application of the process to a morphing leading edge. These results shall be the basis for the development of the morphing kinematics by the involved Clean Sky member(s). Additionally, the applicant will support and validate this kinematics development in Task 3 by 3D CFD analyses of resulting shapes.

The proposed activities can be organised in the following tasks:
Task 1: Method Development
Task 2: Application to morphing leading edge
Task 3: Assessment of morphing leading edge design aerodynamic performance

Tasks		
Ref. No.	***Title – Description***	***Due Date***
1	**Method Development** The method developed in this task should incorporate a given baseline shape and the morphing capability of the material into an aerodynamically optimization of the morphed shape. The objective of this method is to find an optimized target shape which can assuredly be created by morphing with the baseline shape and the selected material(s). A process shall be defined, implemented and prototypically tested for optimizing a shape considering drag, lift and loads of a deformed wing profile and taking into account at the same time mechanical boundary conditions. These mechanical boundary conditions are mainly related to limitations of endurable strain and bending radii limits of the material. Estimations of strains and bending radii (which can also be expressed in terms of strain in a two dimensional analysis in the first step) can e. g. be based on the movement of control points from the retracted to the deployed shape. Besides the extreme-values of strain it is necessary to consider indicators for a high required mechanical complexity as part of the optimization target function. E. g. a smooth strain distribution or the required local radii	M8

Tasks		
Ref. No.	***Title – Description***	***Due Date***
	modifications during morphing might be an indicator for the required number of load introduction points or for the number of sections with different material properties. This task is dedicated to method development. The CfP applicant shall define and implement the process. Additionally, the feasibility of the process shall be demonstrated.	
2	**Application to morphing leading edge** The process defined in task 1 is to be applied to a morphing leading edge using the following input data provided by the Topic Manager: - Retracted shape subdivided in a morphable and a fixed area - A set of material limitations like endurable strains to be used as boundary conditions for aerodynamic performance estimation - Aerodynamic requirements and mechanical boundary conditions for the optimization. This might include boundary conditions like min. /max. values of certain result/performance values or weights indicating the importance of a certain parameter for the optimized result. The CfP applicant shall provide at least six optimized shapes for different sets of requirements (all based on the same retracted shape), representing e.g. different flight conditions or material parameter sets. During execution of this task a continuous communication process on preliminary solutions between the beneficiary and the Topic Manager is expected in order to discuss results in order to achieve the best possible results for the Clean Sky related project. The resulting shapes shall be delivered as a 3D *.stp or *.igs-files. Additionally, the performance indication parameters as well as the estimated strain and pressure distribution shall be documented in a deliverable and shall be delivered in MATLAB *.mat format.	M14
3	**Assessment of morphing leading edge design aerodynamic performance** The resulting shapes derived in task 2 will be the basis for development of the morphing leading edge kinematics and skin design by the Topic Manager. Even though it is envisaged to find a solution which is close to the derived optimized shapes provided by the CfP applicant, it is expected that differences in shape could occur, mainly due to additional requirements that have not been considered during shape optimisation process and related for instance to manufacturing constraints and specific needs. In this task the CfP applicant shall perform a numerical investigation of the aerodynamic performance of the shapes achieved by the kinematics and skin design proposed by the Clean Sky 2 member. These solutions have to be assessed using 3D CFD considering the aerodynamic optimization criteria used in task 2. This assessment of the aerodynamic performance should be performed for up to six different shapes provided by the Clean Sky 2 member. The shapes will be provided based on FE results in *.3dxml format. The computed aerodynamic performance results of the different shapes shall be compared to each other as well as to the performance of	M25

Tasks		
Ref. No.	***Title – Description***	***Due Date***
	the shapes resulting out of task 2. Additionally, the aerodynamic pressure distributions have to be derived.	

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
1	Method for aerodynamic optimization considering mechanical boundary conditions	Report	M8
2	Optimization results for morphing leading edge	Report/ Data	M14
3	Aerodynamic performance estimation of different morphing leading edge design solutions	Report	M25

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
1	Optimization results for morphing leading edge	Report/ Data	M14
2	Aerodynamic performance of selected morphing leading edge design solutions is estimated	Report	M25

Gantt Chart

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
T1								D1																	
T2														D2/M1											
T3																									D3/M2

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

- Experience in using software for computational fluid dynamics (CFD) in numerical aerodynamics
- Experience with optimization tools allowing for integration of aerodynamic performance optimization and mechanical boundary conditions. These might be self-developed tools as well as commercial solutions.
- Experience with stress-/strain analyses of structures, e.g. through Finite Element Analyses.
- Possibility to handle (import/export) the file formats mentioned in the task descriptions: *.igs, *.stp, *.3dxml, *.mat

VII. Development and Manufacturing of Prototype Metallic Parts

Type of action (RIA or IA)	IA		
Programme Area	AIR – WP B-2.2.2		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	750 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	24 months	**Indicative Start Date**[36]	Q2 2017

Identification	Title
JTI-CS2-2016-CFP04-AIR-02-29	**Development and Manufacturing of Prototype Metallic Parts**
Short description (3 lines)	
The aim of this topic is to develop manufacturing processes and techniques pointed to the production of very small batches of metallic parts. The feasibility of these developments will be demonstrated through the smart production of prototype metallic parts for several aeronautical components. The development of these processes should be innovative in order to implement the best performances in the following fields: Low Cost, Energy saving, Flexible and reusable tooling, and Advanced manufacturing techniques The manufactured metallic parts will be delivered to the TM for the assembly of "on-ground" and "in-flight" specimens of the next generation optimized wing box.	

[36] 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 Split-Flap 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 develop and to manufacture all the needed metallic parts for the assembly of the required components of the NGOWB. All the manufactured parts will be delivered at the Topic Manager facility, where the assemblies will be performed.

The selected partner shall develop, manufacture and deliver to the Topic Manager(TM) all the prototype metallic parts in accordance with the technical requirements of the two components and compatible with the standards for a serial aeronautical production/assembly.

The scope of the work includes:

- Development of the manufacturing processes and techniques pointed to the production of very small batches of metallic parts. The feasibility of these developments will be demonstrated through the smart production of prototype metallic parts for several aeronautical components.
- Development and manufacturing of all needed tooling, jigs and templates.
- Manufacturing of all metallic parts, as defined in the Critical Design Review (CDR) for:
  - One (1) “on-ground” tests specimen
  - Two (2) “in-flight” tests specimens (LH + RH)
- CoC (Certification of Conformity) and Quality documentation for all delivered parts.
- Transportation and Delivery of all manufactured parts at Topic Manager facility.

Therefore, the Partner selected for this Call will be the responsible for developing the innovative manufacturing processes, manufacture and deliver all prototype metallic parts for the assembly of the two mentioned end-items, including the transportation and delivery at the facility of the Topic Manager, always in accordance with the materials, manufacturing processes and technical specifications selected or developed by the Topic Manager. All the parts must be delivered with their pertinent Quality and CoC documentation.

2. Scope of work

INTRODUCTION

The objective of most of the technologies involved in the Airframe ITD is to reach a maturity level necessary to allow flight testing of the NGOWB in the Regional Aircraft FTB2, that is based on a platform which 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 metallic parts subject to this topic belong to the wing of the Regional Aircraft FTB2 with reference length 13 m. The main components are shown in Figure 1.

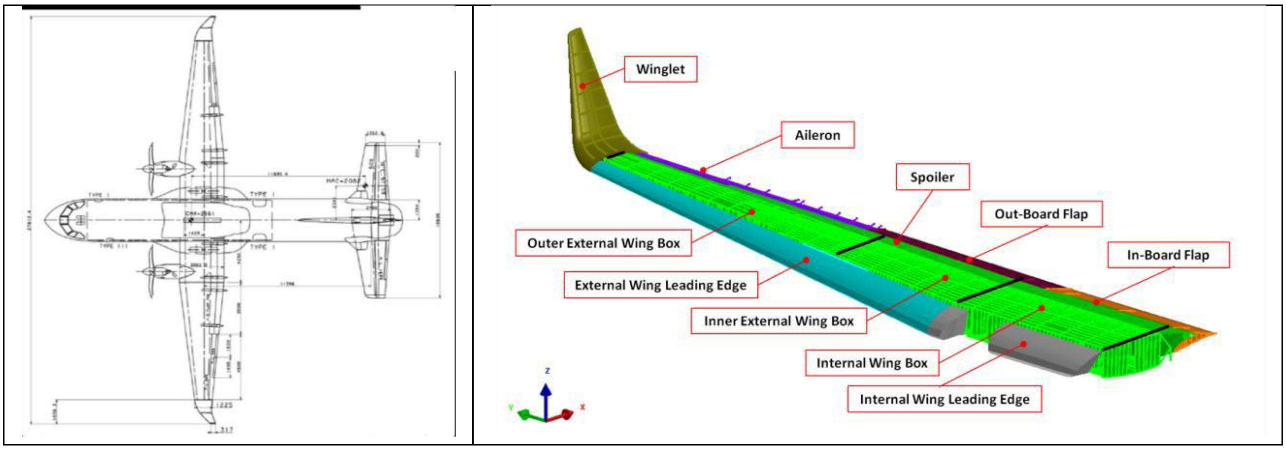


Figure 1. Structural components of the Regional Aircraft FTB2 wing (***)

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:

- Split-Flap Winglet
- Multifunctional Outer Flap, with two flaps tracks for deployment and two actuator attachments.

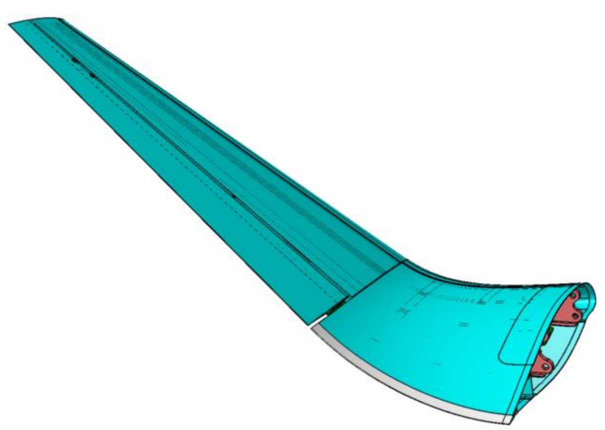
(***) All the Major parts described, the single parts represented in the figures and the geometries, sizes and shapes of all of them are not frozen and are in accordance with the current design status, as it was mentioned in this document. Other possible configurations could be assessed during the CfP application time and therefore these figures and information are just for a preliminary reference. The final configuration will be frozen in the PDR.

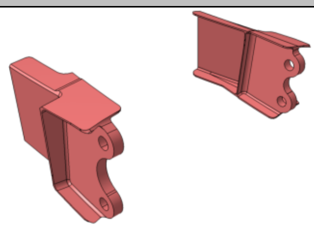
COMPONENT	POSSIBLE TECHNOLOGY CHALLENGES	DIMENSIONS (**)	NUMBER of ELEMENTS
SPLIT-FLAP WINGLET	Reduction of production time. Minimize the number of Auxiliary Tools needed to manufacture the parts. Low Cost & Eco-Design assuring recyclability and reusability.	Reference dimensions: 1300 x 1500 x 1500 mm	• 1 specimen for "on –ground" static and functional tests • 2 specimens (both wings) ready for flight
MULTIFUNCTIONAL OUTER FLAP	Reduction of production time. Minimize the number of Auxiliary Tools needed to manufacture the parts. 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

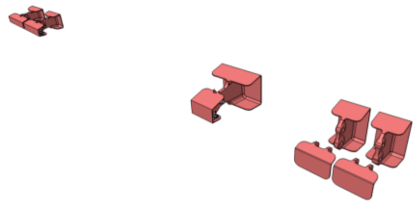
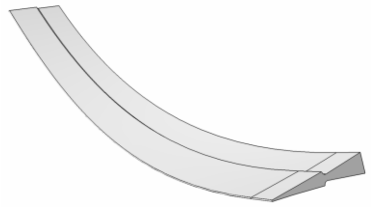
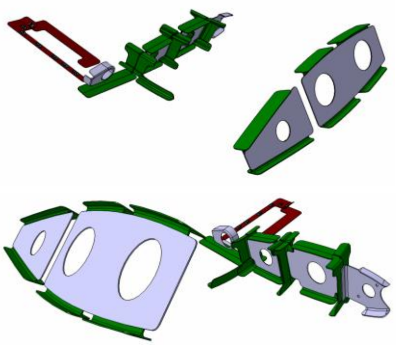
(**)The dimensions Included in this Table are approximately. These values will be frozen during Preliminary Design.

PRODUCT DESCRIPTION

SPLIT FLAT WINGLET

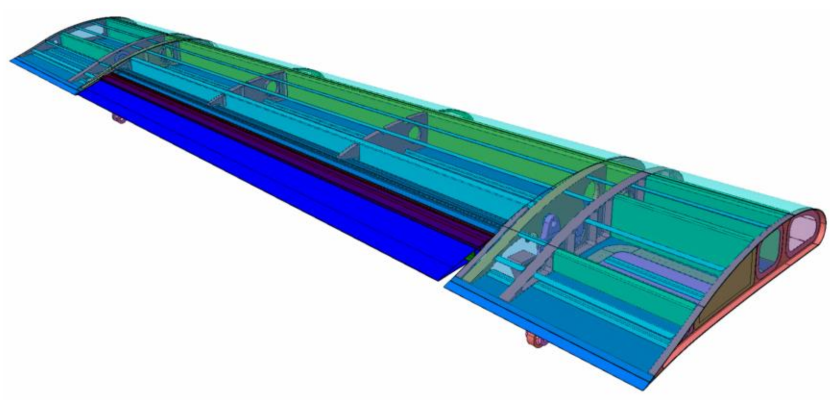


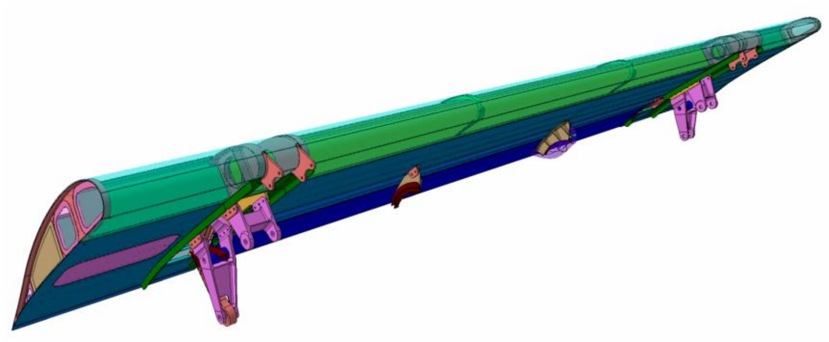
ITEM		
Winglet-Wing attachment Fittings • 1 Front Fitting + 4 Bushing • 1 Rear Fitting + 4 Bushing	**Dimensions:** 225x150x90 mm **Material**: Al 7050 **Manufacturing Technologies**: • Machining • Bushing/Bearing installation	

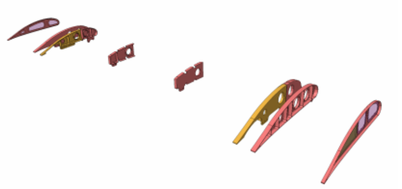
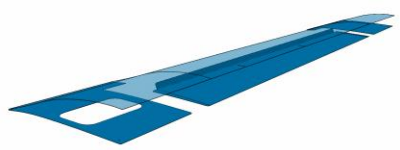
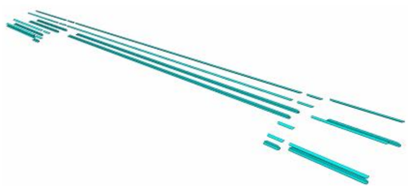
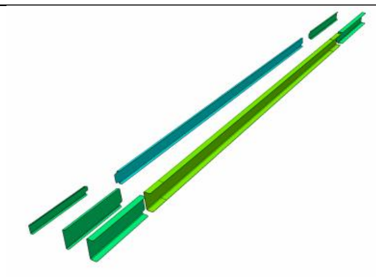
ITEM		
Tab Actuator & Hinge Line Fittings • 4 Actuator Fittings + Bushings • 8 Hinge Line Fittings + Bushings	**Dimensions:** • Max: 225x150x90 mm • Min: 55x50x40 mm **Material**: Al 7050 **Manufacturing Technologies**: • Machining • Bushing/Bearing installation	
Winglet TE End	**Dimensions:** 725x90x15 mm **Material**: Al 2024 **Manufacturing Technologies**: • Machining • Bending/turning	
Ribs, Plates, Splices and Angles.	**Material**: Al 2024 **Manufacturing Technologies:** • Machining • Cutting • Press forming/die forming • Nut Plate installation	

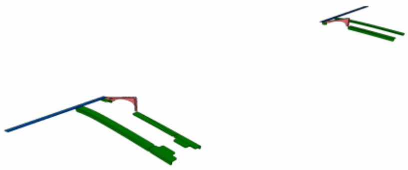
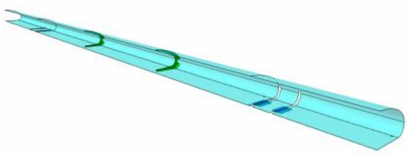
The dimensions and manufacturing technologies are here indicated as reference. The final manufacturing technology will be agreed between the TM and the Partner during the concurrence meetings.

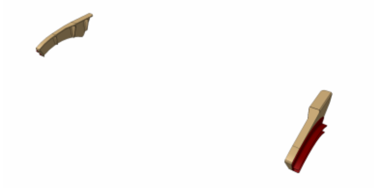
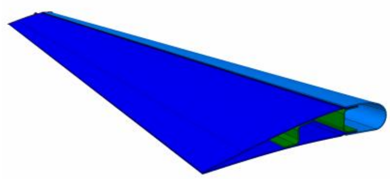
MULTIFUNCTIONAL OUTER FLAP





ITEM		
Flap Ribs • 2 Closing Ribs • 2 Flap Ribs • 4 Box Ribs • 2 LE Ribs	**Dimensions:** max 850x180x30 mm **Material**: Al 2024 **Manufacturing Technologies**: • Machining	
Upper & Lower Skin • 1 Upper • 3 Lower	**Dimensions:** • Max: 3600x800x2 mm **Material**: Al 2024 **Manufacturing Technologies**: • Roll Forming • Bending • Machining • Chemical Milling	
Skin Stringers • 20 Stringers (upper & lower)	**Dimensions:** • 20x20x2 mm Section • Max length: 2300 mm **Material**: Al 2024 **Manufacturing Technologies**: • Machining • Bending/turning	
Spars	**Dimensions:** • Max length: 2300 mm **Material**: Al 2024 **Manufacturing Technologies:** • Machining • Bending	

ITEM		
Rib Post angles and Door Access frames	**Dimensions:** Various **Material**: Al 2024 **Manufacturing Technologies:** • Machining • Bending	
Fairing Angles, TE closing Ribs and TE End	**Dimensions:** Various **Material**: Al 2024 **Manufacturing Technologies:** • Machining	
Leading Edge and Leading Edge Ribs • 1 Sheet metal LE2 Sheet metal Ribs	**Dimensions:** 3600x200x135x2 mm **Material**: Al 2024 **Manufacturing Technologies**: • Roll Forming • Bending • Machining • Press Forming.	
Tab Seal Angle & Plates • 2 Flat Plates • 1 Bended Angle	**Dimensions:** • Max length: 2300 mm **Material**: Al 2024 **Manufacturing Technologies:** • Bending • Machining	
TE Ribs • 2 Ribs	**Dimensions:** 80x50x20 mm **Material**: Al 2024 **Manufacturing Technologies:** • Machining	
TAB HINGE FITTINGS • 2 Fittings	**Dimensions:** 350x100x80 mm **Material**: Al 7050 **Manufacturing Technologies:** • Machining • Bushing Installation	
FLAP TRACK FITTINGS • 2 Fittings	**Dimensions:** 150x110x80 mm **Material**: Al 7050 **Manufacturing Technologies:** • Machining • Bushing Installation	

ITEM		
TAB TRACK SUPPORTS • 2 Supports • 2 Tracks	**Dimensions:** 220x90x25 mm **Material**: Al 7050 **Manufacturing Technologies:** • Machining	
TAB (Sheet Metal) • 1 C-Spar (Bended) • 1 Z-Spar (Bended) • 1 Upper Skin (Roll Forming) • 1 Lower Skin (Roll Forming) • Leading Edge (Press Forming)	**Dimensions:** 2200x90x30 mm **Material**: Al 2024 **Manufacturing Technologies:** • Bending • Roll Forming • Press Forming • Chemical milling • Machining	
TAB TRACKS, FITTINGS AND INNER RIBS	**Various Parts To Be Defined**	

The dimensions and manufacturing technologies are indicated as reference. The final manufacturing technology will be agreed between the TM and the Partner during the concurrence meetings

<u>DELIVERY CONDITIONS</u>

The delivery condition, of the metallic parts will be specified in the COS (Condition of supply) document and Drawings/3D Models. These documents will be developed by the Topic Manager and delivered to the Partner.

All the parts must be delivered in final assembly condition. This includes but is not limited to the following requirements:

- Final Inspection and Quality approval
- CoC (Certificate of Conformity)
- Dimensional /tridimensional inspection and report
- Surface and/or heat treatment
- Chemical Milling
- Painting
- Drilling of TH (Tooling Holes), PH (Pilot Holes) and CH (Coordination Holes)
- Small assemblies: brackets, nut plates, etc installation
- Installation of bearings and bushings.
- Electrical bonding preparation.

The Topic Manager will monitor the Partner for the development and manufacturing of the metallic parts. The prototype metallic parts for the mentioned components will be delivered to the TM, who will be responsible for the end-items assembly. The partner will be responsible of all the manufacturing processes and the tooling needed for the manufacturing of all the metallic parts.

In general and for info, the conceptual design of every component of the NGOWB will be driven by the responsible of the FTB2 platform while 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 all actors for the task to be done in common.
The final requirements and features needed for the Prototype metallic parts will be provided by TM at the beginning of the project with the delivery of the Technical Specification for the Metallic Parts.
The Partner will be supported by the TM during the Prototype Metallic Parts Development and Manufacturing phases.
The Partner will be requested to attend 3 mandatory Concurrence Workshops. They will take place in the facilities of the TM in Madrid (Spain). These workshops will be indicatively held in the following dates:

- By the end of Q1-2017: kick-off meeting
- By the end of Q2-2017: Preliminary manufacturing process Review meeting
- By the end of Q3-2017 (after Demonstrator CDR): Final manufacturing Process Review meeting and parts manufacturing kick-off meeting.

The duration of each of these workshops will be of a maximum of 5 working days (Monday to Friday).

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.
- Test Plan Drafting.
- Assembly Trials Campaign.

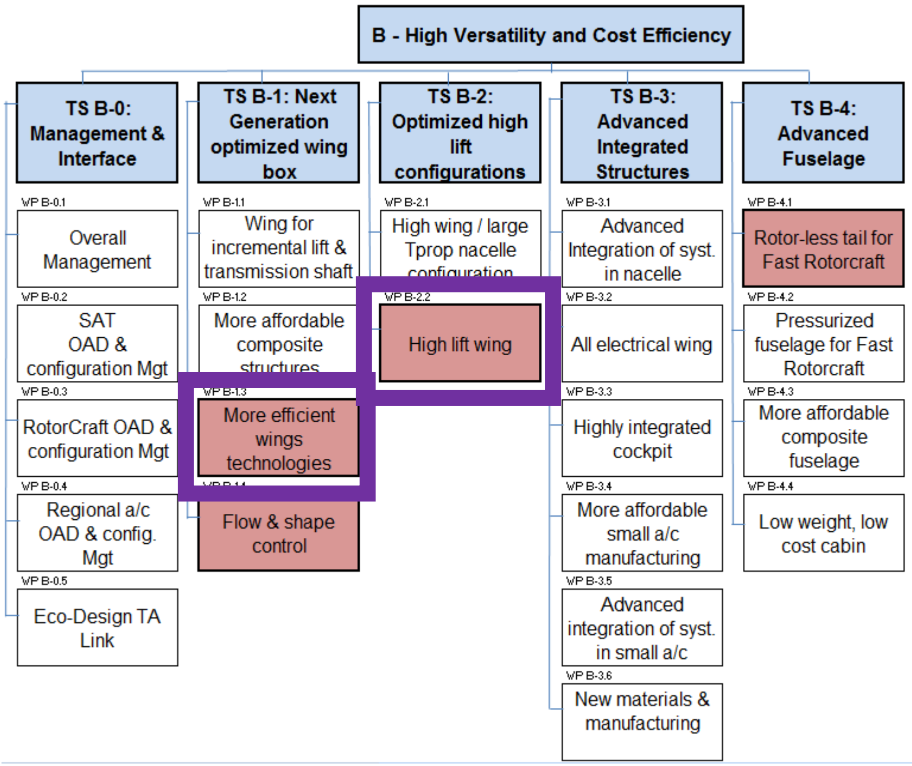
The Partner shall:

- Propose the most suitable and innovative manufacturing process (saving time and energy) for the chosen technology of every Single Part. Each part will require all the necessary tooling (jig, drill, lift, etc.) to produce a part in accordance with the drawings. The number of these tools should be reduced by the use of innovative manufacturing technologies in order to achieve the already said targets in terms of time and energy reduction.
- Design and develop all the manufacturing processes and work orders needed to manufacture the parts.
- Define, design and manufacture all the tooling necessary for the manufacturing of the parts.
- Generate and deliver the documentation in accordance with the Core Partner specification.
- Delivery of the Parts to the TM.
- Support the Set up in the TM facilities.
- Modify the manufacturing processes and technologies if there are design modifications after the CDR. Impact limits of this kind of modification (if needed) will be negotiated.
- Follow up of the works performed by the TM until the end of the prototype assembly phase. Support the TM during the assembly activities in case any incident happens during the period:
    - Any deviation is found in the metallic parts

- A rework is requested in any metallic part due to assembly needs.
- A part is scrapped during the assembly and a spare part is needed.

- It will be appreciated and desirable if the defined manufacturing processes reduce the standard manufacturing Lead-Time
- The implementation of an innovative and low cost concept in terms of Materials and Design processes will 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 the Regional Aircraft FTB2 is enclosed.



The TM will provide the information (design documentation, general requirements specifications, etc.) to the partner in order 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:

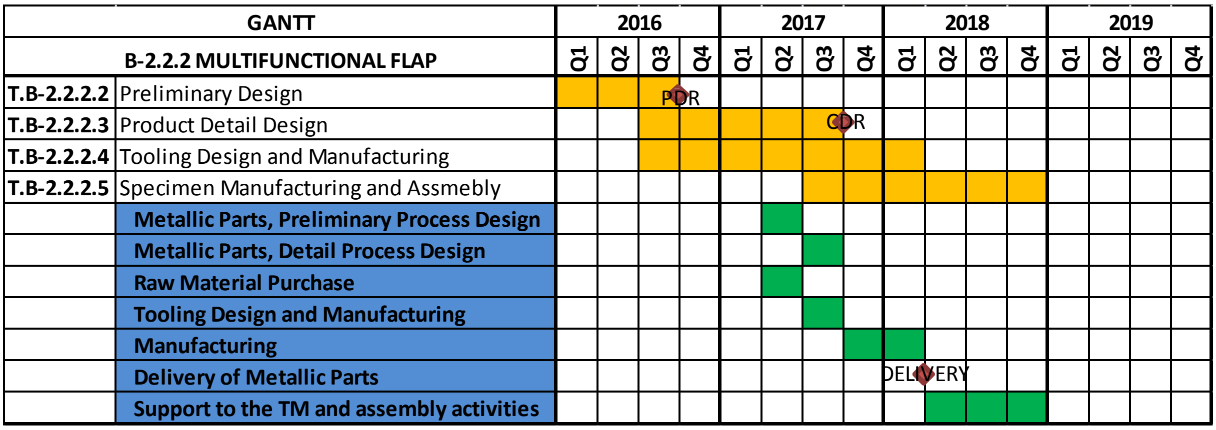
- Method and Tool harmonization (substantiation, IT, Program management)
- Quality assurance process harmonization
- Communication management
- Content of substantiation file (if needed for prototype metallic parts)

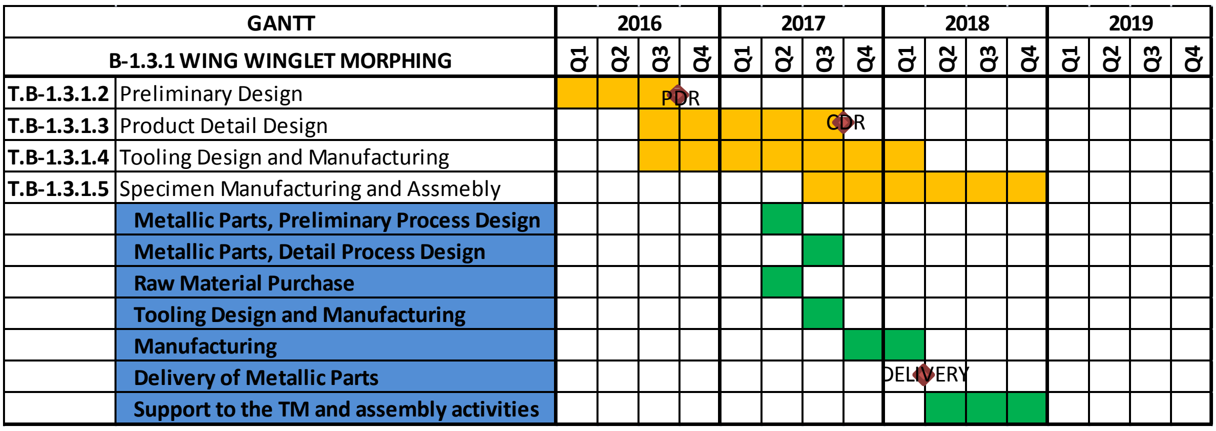
Parts manufactured within this CfP will be tested on-ground and in flight. Thus, the process needs to support a Permit – to – Fly with Airworthiness Authorities.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T1	Preliminary Manufacturing Process of the Metallic Parts	T_0+3M
T 2	Tooling List & Concepts	T_0+3M
T 3	Final Manufacturing Process of the Metallic Parts	T_0+6M
T 4	Tooling Manufacturing	T_0+6M
T 5	Raw Material Purchase	T_0+6M
T 6	Manufacturing and delivery	T_0+12M
T 7	Support the TM and Assembly activities	T_0+24M

3. Major deliverables/ Milestones and schedule (estimate)

In the pictures below a Planning with the main activities to be developed by the Partner is shown. The tasks to be performed by the Partner are highlighted in blue and as reference their relation with the main design and assembly activities is shown.





Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Detailed Planning of the activities to be performed in order to deliver the parts within the Target Date.	Planning	T_0 + 1M
D2	Preliminary Risk Analysis	Risk Analysis	T_0 + 1M
D3	Manufacturing Capabilities	Report	T_0 + 1M
D4	Preliminary Process Design	Report	T_0 + 3M
D5	Detailed Risk Analysis	Risk Analysis	T_0 + 3M
D6	Quality Assurance Plan	Report	T_0 + 4M
D7	Tooling List	Report	T_0 + 4M
D8	Outsourcing Plan and involved subcontractors	Plan	T_0 + 6M
D9	Final Process Design	Report	T_0 + 12M
D10	Work Orders	Report	T_0 + 12M
D11	Quality inspection reports- CoC	Report – CoC	T_0 + 24M
D12	Delivery of Metallic Parts	Parts	T_0 + 24M

*T_0 Is the starting date of the activities to be performed by the applicant.

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 - Condition of Supply of the Metallic Parts – Preliminary	Report Drawings	T_0
2	Assembly Processes: - Proposed materials and assembly processes		T_0
3	Technical documentation from Components CDR: - CATIA Models and drawings from CDR - Condition of Supply – Final		T_0 + 9M

**T_0 Is the starting date of the activities to be performed by the applicant.*

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

(M) – Mandatory; (A) – Appreciated

- Experience in the manufacturing of innovative metallic components (M)
- Design tools of the aeronautical industry: i.e. CATIA v5 r21 (M)
- Experience in management, coordination and development technological (Aeronautical) programs. (M)
- Proved experience in collaborating with reference aeronautical companies with industrial air vehicle developments with "in – flight" components experience. (M)
- Participation in international R&T projects cooperating with industrial partners, institutions, technology centres, universities and OEMs (Original Equipment Manufacturer). (A)
- Competence in management of complex projects of research and manufacturing technologies. (A)
- Quality System international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004). (M)
- Manufacturing and/or outsourcing Capabilities according to the described manufacturing technologies (M)
    - Machining
    - Bending
    - Roll forming
    - Press Forming
    - Heat Treatment
    - Surface Treatment
    - Chemical Milling
    - Painting
    - Dimensional and Tridimensional Inspection
    - Non-Destructive testing
    - Bushing and Bearing assembly
- OEM standard Qualification for Manufacturing Special Processes (M)
- 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).

5. Abbreviations

TRL	Technology Readiness Level	M&A	Mounting and Assembly
OoA	Out of Autoclave	QG	Quality Gate
RTM	Resin Transfer Moulding	R/C	Rotor Craft
SQRTM	Same Qualified Resin Transfer Moulding	RRs	Roles and Responsibilities
LRI	Liquid Resin Infusion	TBC	To Be Confirmed
IR	Infra Red	TBD	To Be Defined
XCT	X-ray Computerized Tomography	VS	Vertical Stabilizer

POA	Production Organization Approval	WBS	Work Breakdown Structure
DOA	Design Organization Approval	WP	Work Package
EASA	European Aviation of Safety Agency	COS	Conditions of Supply
FAA	Federal Aviation Administration	SPC	Super Plastic Forming
LCA	Life Cycle Analysis	ALM	Additive Layer Manufacturing
LCCA	Life Cycle Cost Analysis	AHE	Airbus Helicopters Spain
OEM	Original Equipment Manufacturer	CfP	Call for Partner
R&T	Research and Technology	CI	Configuration Items
NDI	Non Destructive Inspection	HS	Horizontal Stabilizer
IP	Intellectual Property	HVE	High Versatility and Cost Efficiency
CoP	Core Partner	IAW	In Accordance With
ISC	In-Situ Co-consolidation	ITD	Integrated Technology Demonstrator
TU	Tail Unit	JTP	Joint Technical Programme
SMR	Structural Manufacturing Responsible	SDR	Structural Design Responsible
CS	Control Surfaces	NGOWB	Next Generation Optimised Wing Box

VIII. Development and Manufacturing of Innovative Stamping Dies for Aluminium Ribs Hot Stamping

Type of action (RIA or IA)	IA		
Programme Area	AIR – WP B-2.2.1 External wing box. Ribs		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	350 k€	Type of agreement	Implementation Agreement
Duration of the action (in Months)	12 months	Indicative Start Date[37]	Q2 2017

Identification	Title
JTI-CS2-2016-CFP04-AIR-02-30	Development and Manufacturing of Innovative Stamping Dies for Aluminium Ribs Hot Stamping
Short description (3 lines)	
The objective is to develop an innovative Stamping die concept based on a modular / reconfigurable and low cost approach for the manufacturing of aluminium hot stamped wing ribs ready to fly. Technologies applied shall consider: ▪ Economic and environmental sustainability: moulds at an affordable cost using materials and processes sustainable with the environment (e.g. less raw material) ▪ Productivity: reliable moulds that allow increasing the productivity and reducing maintenance periods / costs. ▪ Monitoring to control process parameters and also health monitoring of the mould itself. Flexibility (different shape configurations of the mould), facilitate mounting and dismounting, customization and functionalization.	

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

1. Background

This project is part of the Airframe ITD, which one of the aims is to design and manufacture aeronautical components for Regional Aircraft FTB2 that is based on a platform which is Civil FAR 25 certified by FAA and EASA Airworthiness Regulations with large in-service experience as regional aircraft and which is a suitable platform to test in flight Clean Sky 2 mature technologies.
The activities required for this topic are linked to the Optimized high lift configuration (TS B-2), High Lift Wing, External wing box (B-2.2.3) Technology Streams of the Airframe ITD.
One of the main technological challenges is focused on flight elements of primary and secondary structure made on highly deformed light alloys, integrating design details for stabilization against buckling of crippling failure modes and using enhanced material/process properties with respect to a reference. The Outer External Wing Ribs have been selected as application where innovative materials and manufacturing processes will be applied.

2. Scope of work

When aluminium sheets are formed at room temperature as in conventional sheet metal forming processes, they exhibit low formability and marked spring-back for stamping accurate parts with a complex geometry. An increase of the formability and a drastic reduction of spring-back can be achieved if the process is carried out at elevated temperatures.

High production volumes and economic competitiveness could be achieved by means of **Hot Stamping process** in which operations are carried out in hot deformation conditions and high strain rates. The combination of this technology with high performance aluminium alloys (e.g. Scandium reinforced aluminium alloys) offer numerous advantages as the increase of the formability (allowing deeper shapes), improvement of component tolerances, reducing the weight of the final component (higher strength materials) and reducing its cost (e.g no need of heat treatments, reduction of piece number in the component, etc.).

Stamping dies are key elements required to obtain good quality components. They also play an important role in the final cost of the component. In the development of the stamping dies, the economic and environmental sustainability, productivity, flexibility and monitoring possibility needs to be considered.

The **main objective** of this project is to develop and manufacture an innovative stamping die based on a modular/reconfigurable and low cost approach. The die will serve to manufacture different left and right hand aluminium ribs corresponding to the outer external wing of FTB2 demonstrator.
Die materials shall have good wear resistance over a wide temperature range and a good thermal conductivity. In addition, factors as tolerances, efficient material usage and maintenance will have to be considered. Thanks to the modularity and versatility of the die, it has to be possible to use the die to stamp different length / shape components (i.e: left and right hand side ribs, different size ribs).

Details related to the component to be developed will be provided once the activity is initiated but a size of 800 mm x 300 mm could be taken as a general envelop. Aluminium sheets will be heated at a temperature around 400 ºC – 500 ºC. Uniform thickness and properties shall be obtained all along the component and design details being implemented.

Parts manufactured by this process will be tested on-ground and in flight. Thus, the process needs to support a Permit – to – Fly with Airworthiness Authorities. Therefore, dies quality need to be sufficient for this purpose.

The tooling shall be delivered to the Topic Manager (TM) facilities for the manufacturing of the demonstrators.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T1	Review of the components to be manufactured with the dies (info provided by the TM) and definition of specifications the hot stamping die shall fulfil	T0 + 2M
T2	Conceptual design of the stamping die. Modular, reconfigurable and low cost concepts shall be analyzed and traded off. Material, coating needs, cooling strategy shall be assessed.	T0 + 6M
T3	Detailed design of the selected concept (including the required analysis and manufacturing plan)	T0 + 8M
T4	Manufacturing of the stamping die shall be performed. Differences with respect to the manufacturing plan identified in T3 will be reported.	T0 + 10M
T5	Manufacturing trials: The applicant shall deliver the prototype tooling to TM's premises and shall support its set up for manufacturing trials.	T0 + 12M

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Specifications of the stamping die	Report	T0 + 2M
D2	Conceptual design of the stamping die	Report, drawings	T0 + 6M
D3	Detailed design of the stamping die	Report, drawings	T0 + 8M
D4	Stamping die	Hardware	T0 + 10M
D5	As built of the stamping die and user's manual	Report	T0 + 12M

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Stamping die conceptual design	Review	T0 + 6M
M2	Stamping die ready for manufacturing	Review	T0 + 8M
M3	Stamping die delivery and support	Review	T0 + 12M

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

The design and manufacture of metal stamping dies is a process requiring highly skilled designers and master craftsmen.

The following skills are required:

- Experience in design, analysis and manufacturing of stamping dies.
- Capacity and skills for metal-working, machining and, tooling inspection.
- Expertise in sensorization, monitorization.
- Surface engineering / coatings knowledge.
- Quality Systems international standards (i.e EN 9100:2009 / ISO 001:2008 / ISO 14001:2004)

IX. Numerical methodologies and related tools for effect of defect prediction in manufacturing

Type of action (RIA or IA)	RIA		
Programme Area	AIR – WP B 3.3.2		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	500 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	36 months	**Indicative Start Date**[38]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-AIR-02-31	**Numerical methodologies and related tools for effect of defect prediction in manufacturing**
Short description (3 lines)	
This research activity aims at developing innovative numerical methodologies to address effect of defect in large aircraft subcomponents. First defect formation, location and densities occurring in the manufacturing phase will be investigated and integrated into numerical modelling in order to improve representativeness and prediction robustness from coupon to subcomponent levels. Additionally a probabilistic approach will be developed to complement numerical predictions with associated scatters of results.	

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

1. Background

The current development proposed in this Call will be done in the frame of Clean Sky 2 aiming to maturing and validating disruptive technologies for the next generation Large Passenger Aircraft (LPA) through large scale integrated demonstrators.
This call is related to activities running under the *ITD Airframe Part B WP B-3.3* oriented towards highly integrated cockpit but more specifically towards *"LPA Cockpit innovative structural components" WP B-3.3.2* as presented in the work breakdown structure below.

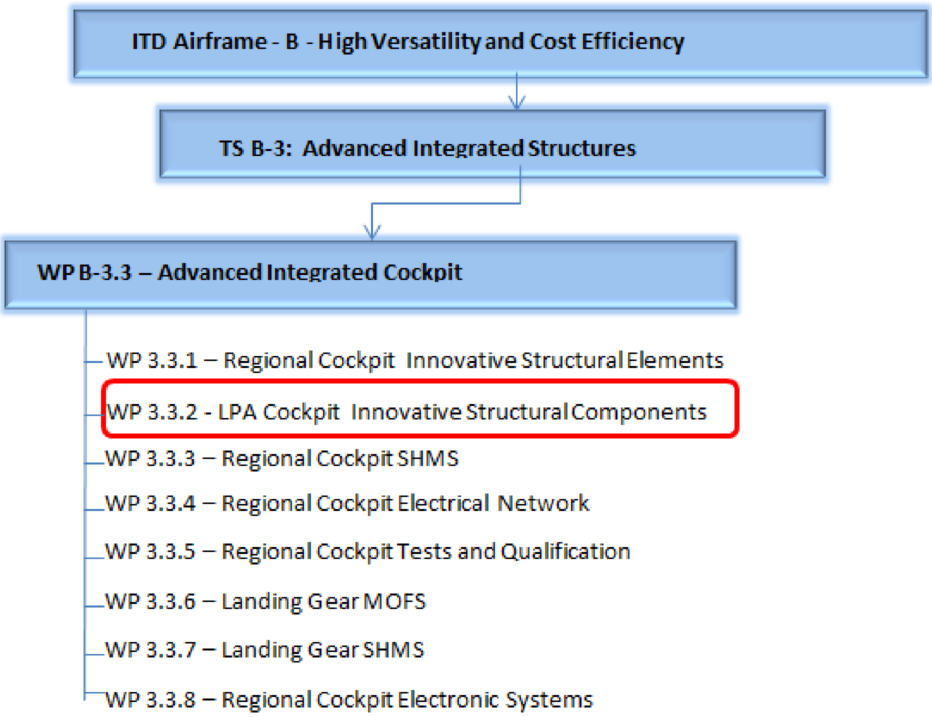


Figure 1 – WBS of ITD AIRFRAME –B High Versatile High Versatility and Cost Efficiency -WP B-3.3

The current Call outcome will be the input to the *LPA technology demonstrators* developed within *Platform 2 "Innovative Physical Integration Cabin – System – Structure"*. The Topic Manager will define the applicable context related to the demonstrator design, manufacturing and testing for proof of concept.
A first high level objective to which this current Call will contribute is to support aircraft design but also replace physical testing by numerical analyses, namely Predictive Virtual Testing (PVT). A key requirement is that numerical analyses must predict all damages and failures modes at both material and component levels.
A second high level objective is to accelerate the trend towards simulation based Means of Compliance (MoC) with regards to aircraft certification and to promote numerical analysis as a secured certification MoC acknowledged and validated by the civilian Aviation Authorities.

The current Call is aiming at expanding design space, reducing development costs and lead time by increasing prediction accuracy and robustness. This will be achieved by routinely accounting, in numerical analyses, of

component mechanical variability issued from manufacturing.
A deterministic analysis with a single prediction of behaviour is not sufficient anymore to provide higher confidence in numerical tools. Providing the validity envelop of the prediction is equally important and enables to establish thresholds at which defects can potentially affect the component mechanical integrity.

The applicant(s) shall develop a methodology and associated tool handling manufacturing uncertainties in the modelling process of aircraft components. For instance, defects types, sizes and locations will be identified and integrated to numerical analyses based on a probabilistic approach, which will evaluate most damaging defects to the mechanical behaviour of components. Such an approach needs to be robustly implemented and coupled to Topic Manager standard numerical analyses making it part of the modelling process.

2. Scope of work

The applicant(s) shall perform an assessment of all the sources of defects such as,

- Fibre wrinkling
- Porosity
- Fibre misalignment

which can occur during manufacturing process. An assessment of the relative importance of each defect on the accuracy of the numerical prediction will be conducted in a second phase. This will have to be clearly quantified using a probabilistic approach such as plan of experiment in order to provide result scatters associated to each variables such as: defect type, defect size, etc. From this probabilistic investigation coupling numerical analyses and Plan of Experiment, a ranking of variables will be defined by the applicant(s).
The applicant(s) shall deliver a probabilistic Toolkit, which will enable to run efficiently and automatically batch of numerical analyses by changing defects variables through a Plan of Experiment. The method supplied will need to be the most practical solution for airframe structural analysis based on considerations, such as ease-of-use, availability, compatibility with existing tools, computational efficiency, etc.
It will be needed to demonstrate through use cases that the confidence levels in predictions made in advance of any tests being conducted are validated with test results falling within the calculated confidence levels.
Finally, the applicant(s) will assemble all required tools and deliver them to industrial partners for exploitation. The newly created probabilistic Toolkit will have to be compatible with the tools currently used within Topic manager facility. The applicant(s) will provide all the necessary training and support for full familiarisation with the tool to the level where it can be used independently and with confidence.

Tasks		
Ref. No.	***Title – Description***	***Due Date***
1	Management and Co-Ordination	M0 + 36M
2	Survey of manufacturing defects in aircraft predictive virtual simulations	M0 + 3M
3	Prototype probabilistic Toolkit for Structural Analysis Simulations	M0 + 12M
4	Benchmark for probabilistic Toolkit validation	M0 + 24M
5	Effect of manufacturing defect methods implementation to CleanSky 2 demonstrators	M0 + 36M

Task1: Management and coordination

The applicant will manage and coordinate the project and ensure due course of the project by respecting deliverables and milestones. Regular reporting via emails, WebEx or meetings will be given to the Topic Manager in order to achieve progressive internal dissemination.

Task2: Survey of manufacturing defects in aircraft predictive virtual simulations

The applicant shall perform an assessment of all the sources of defects resulting from manufacturing process and assess their relative importance on the accuracy of the numerical analysis. The level of uncertainty that may be expected for each variable considered, with associated scatter shall also be addressed to allow a probabilistic approach to be adopted in the other tasks. Based on a "qualitative" approach, a ranking of each source of defect types, sizes and locations shall be proposed.

Task 3: Prototype Probabilistic Toolkit for Structural Analysis Simulations

The applicant(s) shall deliver a prototype Probabilistic Toolkit for Structural Analysis Simulations. It will have to be compatible with Topic Manager standard tools for CAD (Computer Aided Design) and for finite element software.

Task 4: Benchmark for Probabilistic Toolkit validation

To benchmark the Probabilistic Toolkit, the Topic Manager will supply a first use case, such as coupon, for the applicant(s) in order to investigate effect of defects. The applicant shall provide a prediction of the structural behaviour, which will include a prediction of the potential scatter of results. The Topic Manager will then supply physical tests results on the use case structure. All test results should fall within the predicted scatter. If this is not achieved some explanation as to why this did not occur will be required.

The Topic Manager will supply a second use case, such as a stiffened panel (2x2 meters with omega stinger), and the process will be repeated. If the experimental results do not fall within the identified error bounds again, a strong technical argument will be needed to explain why this is the case.

Task 5: Probabilistic Toolkit implementation to CleanSky 2 demonstrators

The applicant(s) will benchmark and demonstrate the probabilistic approach developed in tasks 3 and 4 to the

CleanSky 2 demonstrator. This will involve the execution and demonstration of the process on benchmark use cases of relevant part of the lower centre fuselage demonstrator. The selection will be coordinated to the design of Platform 2 demonstrators.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
1	Document describing sources of manufacturing uncertainty in predictive virtual simulation of aerospace structures and their potential impact on the accuracy results	Report	M0 + 3M
2	Proposed approach for Probabilistic Approach for predictive Virtual Simulation of Aerospace Structures	Report	M0 + 6M
3	Use Case 1 blind simulations and confidence level prediction	Simulation Prediction with Uncertainty Assessment	M0 +15M
4	Evaluation of predictions for Use Case 1 against experimental results	Report	M0 + 18M
5	Use Case 2 blind simulations and confidence level prediction	Simulation Prediction with Uncertainty Assessment	M0 + 21M
6	Evaluation of predictions for Use Case 2 against experimental results	Report	M0 + 24M
7	Delivery of Prototype Probabilistic Capability for industrialisation and implementation into CleanSky 2 demonstrator	Software with Documentation / Training Manuals (as appropriate)	M0 + 33M
8	Final Report – Summarising Findings of complete project	Report	M0+34M

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
1	Review of prototype probabilistic toolkit compatible - initial demonstration	Review/Minutes of Meeting with Actions	M0 + 12M
2	Lessons Learnt Review from Use Case 1	Review/Minutes of Meeting with Actions	M0 + 18M
3	Lessons Learnt Review from Use Case 2	Review/Minutes of Meeting with Actions	M0 + 24M
4	Final Project Review	Minutes of Meeting	M0 + 35M

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

Mandatory skills:

- Familiar with Aircraft design and certification process
- Applicant(s) will need to be specialist(s) in advanced structural numerical analysis with special interest in failure modelling. This would ideally include modelling of,
    - aircraft components and assemblies
    - metallic and composite materials, bonded and bolted joints
- Applicant(s) shall have experience with probabilistic methods (e.g. Monte Carlo, Latin Hypercube, Mean Value Method, 1st and 2nd order Reliability Methods, etc.) and have used tools, such as OpenTurns
- Applicant(s) shall have extended experience with the commercial finite element code Abaqus

Mandatory equipment:

- Sufficient Abaqus licences to run large model (>3million elements)
- High Performance Computing resources to ensure that large model (>3million elements) can be investigated

X. Testing Matrix Optimization by Interaction Between Numerical Modelling and Innovative Non-Contact Measurement Technology

Type of action (RIA or IA)	IA		
Programme Area	AIR – WP B 3.3.2		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	500 k€	Type of agreement	Implementation Agreement
Duration of the action (in Months)	36 months	Indicative Start Date[39]	Q2 2017

Identification	Title
JTI-CS2-2016-CFP04-AIR-02-32	Testing Matrix Optimization By Interaction Between Numerical Modelling And Innovative Non-Contact Measurement Technology
Short description (3 lines)	
This project will develop smarter testing methods and define protocols to provide the framework for quantitative correlation of structural test and simulation data. To improve and simplify the validation of new simulation methods advanced measurement and correlation techniques will be developed and implemented in test trials which will be performed according to the framework protocols.	

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

1. Background

The current development proposed in this Call will be done in the frame of Clean Sky 2 aiming to maturing and validating disruptive technologies for the next generation Large Passenger Aircraft (LPA) through large scale integrated demonstrators.

This call is related to activities running under the *ITD Airframe* (*Part B WP B-3.3*) oriented towards highly integrated cockpit but more specifically towards *"LPA Cockpit innovative structural components" (WP B-3.3.2)* as presented in the work breakdown structure below.

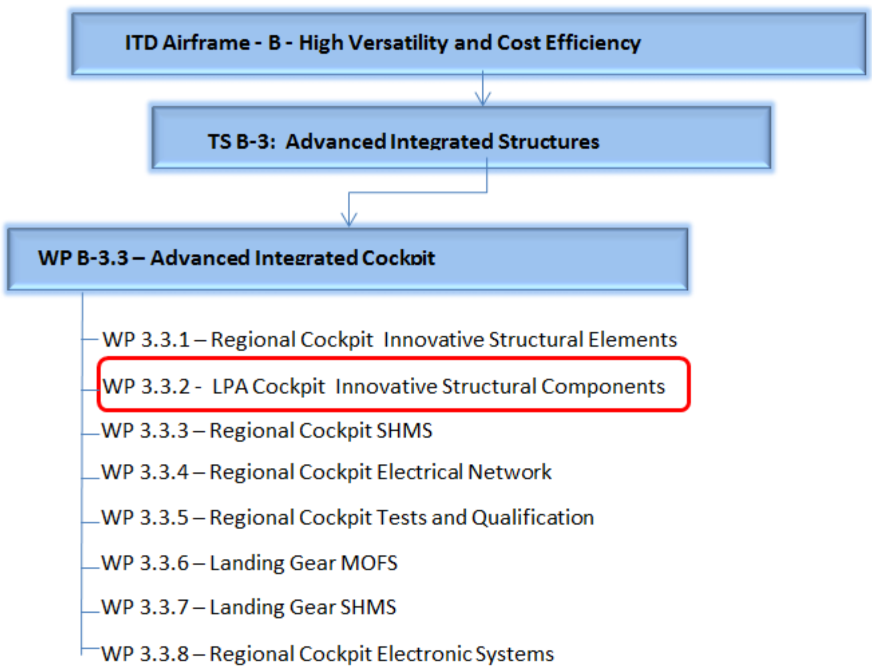


Figure 1 – WBS of ITD AIRFRAME –B High Versatile High Versatility and Cost Efficiency -WP B-3.3

In order to achieve enhanced aircraft performance, reliable light-weight designs are required based on predictive finite element simulation tools. However, to meet the required reliability additional safety factors are used which leads to conservative designs. To optimize these safety factors engineers must have a very high level of confidence in the numerical simulations and the test data supporting them. It can be attained by automatic and robust protocols for validations.

The expected outcome of this Call is an innovative method with related software tool for structural test data acquisition and correlation with predictive Finite Element models, named "Testing Matrix". This innovative approach to validation will use full-field data correlation allowing the maximum use of high density data by comparison of all the data generated in the simulation with all of data measured in the test.

The current Call outcome will be the input to the *LPA technology demonstrators* testing phase within *Platform 2 "Innovative Physical Integration Cabin – System – Structure"*.

Key developments expected during the project:

- Develop robust and repeatable methods for the quantification of uncertainties of Digital Image Correlation (DIC) measurements in an industrial environment
- Produce advanced structural test protocols and develop methodology for validation of simulation data
- Deploy validation methods and test protocols demonstrated through a structural test case that will be defined by the Topic Manager. The Topic Manager will define the applicable context related to the typical demonstrator design and testing condition for proof of concept.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
1	Develop methodologies for validation of simulations	M0 + 12M
2	Industrialize the quantification of measurement uncertainty for DIC	M0 + 18M
3	Produce protocols and best practice for validation methods	M0 + 24M
4	Deploy protocols and implement validation methods demonstrated during structural test	M0 + 36M

T1 Develop methodologies for validation of simulation tool

For this task, the applicant(s) shall develop novel methods for comparison of predictive numerical models with full-field experimental data in order to achieve a robust quantitative validation of the simulation, as illustrated in Figure 2.

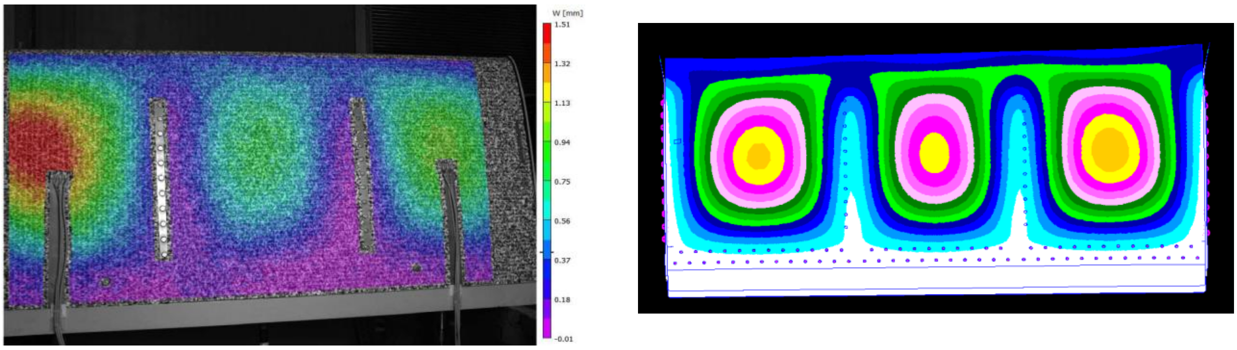


Figure 2 Example of DIC experimental and FE simulation data

The applicant(s) shall address the following topic areas,

- Understand uncertainties in simulation and experimental data and their influence on predictions and test results
- Develop simple and relevant criteria to allow easy comparison and interpretation of the experimental and simulation data
- Propose novel correlation methods that will satisfy the criteria for the evaluation of the comparison developed in this work package.

T2 Industrialize the quantification of measurement uncertainty for DIC

For validation purposes, it is vital to establish uncertainties in source data. For this task, the applicant(s) will develop a specific method for validation of optical measurement systems, such as Digital Image Correlation (DIC), which can be deployed at the time of test alongside the test article to quantify the measurement uncertainty across the whole measurement control volume.

This task will involve carrying out a State-of-the-Art evaluation of the newly proposed validation method, and execution of benchmarking tests to produce a standard process for validation of 1:1 aircraft scale optical displacement and strain measurement systems.

The Topic Manager will provide dedicated test on which the applicant(s) will investigate the effects of the optical system parameters on uncertainties in the results, and to achieve a comprehensive understanding of the limitations of this concept. Once the validity and limitations of this method are understood, methods and tools shall be developed.

The developed tool will facilitate the integration of new analysis algorithms, and will permit the control of test hardware during the implementation of the novel validation methods developed in Task 3.

T3 Produce protocols and best practice for validation methods

The applicant(s) shall create a new test request and test definition protocol, to specifically suit the validation purposes. The protocols will ensure that test and simulation are 'intertwined' allowing for a rigorous, robust and valid comparison. The applicant(s) shall propose the protocol for a "Validation Methodology" for aircraft subcomponent specimens, such as part of lower centre fuselage.

T4 Deploy protocols and implement validation methods demonstrated during structural test

In order to demonstrate that the protocols and validation methods meet the advanced requirements, the demonstration will be conducted in the Topic Manager facility on a 1:1 scale structural test bench unit, for instance during static test.

During test, the applicant(s) shall follow the new protocol and its validation will be jointly conducted with Topic Manager. Provision for potential improvements must be planned.

A double-blind test supported by the Topic Manager will be declared for the duration of the test and data post-processing which will ensure that no bias will occur in the results from either the simulation or the experimental activity.

3. Major deliverables/ Milestones and schedule

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date (Months from start)***
D1	Develop methodologies for validation of simulations	Report	M0 + 12M
D2	Industrialize the quantification of measurement uncertainty for DIC	Report- Software tool & Demonstration	M0 + 18M
D3	Produce protocols and best practice for validation methods	Report	M0 + 24M
D4	Deploy protocols and implement validation methods demonstrated in a ‘double blind’ test	Report & Demonstration	M0 + 34M

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M0	Project kick-off	Meeting	M0
M1	Detailed technical project plan and demonstration schedule established and agreed	Meeting	M0 + 12M
M2	Draft report for protocols and best practice for validation methods	Meeting	M0 + 24M
M3	Passed validation ‘double blind’ test readiness review	Meeting	M0 + 34M
M4	Final Project Review	Meeting	M0 + 35M

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

Mandatory skills:

- Expertise and contribution to scientific development and practical understanding of the Digital Image Correlation technique for deformation measurement in an industrial testing environment,
- Track record of performing structural test simulations in aircraft industrial sector, and their validation using experimental methods such as full-field data comparison using point to point comparisons and image decomposition,
- Proven experience in creating and running testing programmes, and experimental stress analysis skills that will contribute to the definition of correlation criteria,
- A track record of creating process documentation for industrial deployment of test procedures,
- Experience & Capability to develop software and IT tools related to the described tasks, to facilitate the integration of new analysis algorithms, and to permit the control of test hardware during the

implementation of the novel validation methods developed during the project.
- Applicant(s) shall have extended experience with the commercial finite element code Abaqus

Mandatory equipment:

- Sufficient Abaqus licences to run large model (>3million elements)
- High Performance Computing resources to ensure that large model (>3million elements) can be investigated

XI. Developing Innovative Joining Concepts and their Manufacturing Methodologies

Type of action (RIA or IA)	IA		
Programme Area	AIR / SAT - WP B 3.4.2		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	500 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	30 months	**Indicative Start Date**[40]	Q2 2017

Identification	Title
JTI-CS2-2016-CFP04-AIR-02-33	**Developing Innovative Joining Concepts and their Manufacturing Methodologies**
Short description (3 lines)	
Improvement of mechanical and electrical properties of joints, their durability and resilience against environmental and operational effects, and facilitating their manufacturing and integration into the real aircraft structure.	

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

1. Background

The ever increasing amount of composite parts being integrated into the aircraft structure leads to proportionally increasing number and diversity of hybrid composite-metal interfaces. Traditionally, designers have been avoiding such dissimilar hybrid joints due to a lack of adequately comprehensive test data and limited knowledge how to properly manufacture them.

Designing metal-composite hybrid joints is clearly a complex multidisciplinary task. Many of the well-known weaknesses of the design are closely related to the material diversity of the junction, i.e. different properties of the metallic and composite counterparts such as different elasto-plastic behaviours, influence of anisotropy, sensitivity to the type of loading, impact resistance, different failure mechanisms, fatigue behaviour, coefficients of thermal expansion or environmental resistance. It is obvious then that different materials need different design procedure.

Besides defining the laminate stacking which by itself is a challenging task, there is little information about the strength of a particular laminate in combination with a particular fastening element. Thus, sizing of the joints is somewhat a tedious task and requires an enormous amount of test data. The resulting performance of the joint is also highly sensitive to the quality of manufacturing which, given the fact that laminates of complex shapes are very often hand-crafted, usually results in oversizing of such parts to account for human errors. Moreover, it is often necessary to guarantee a conductive connection between the neighbouring parts to provide means of conveying surface electric currents in case of lightning strike or HIRF events. Hand in hand with these electromagnetic events, protection against the damage caused by magnetic forces, excessive heating and sparking needs to be guaranteed too. Covering the composite parts with different kinds of protective layers or paints and providing proper connection to the surrounding structure makes the design and sizing of metal-composite joints even more challenging.

Currently, the thin-walled composite parts are treated similarly to other thin-walled metallic parts, i.e. either by riveting to the surrounding structure or by bolting to metallic hinges. These approaches, however, do not account for specific needs of composites and sacrifice some of the composite potential since the joint surrounds have to be excessively reinforced. In general, the process of sizing relies mainly on introducing multiple conservative coefficients to account for uncertainties where comprehensive test data are missing.

Recently, many research studies have been carried out addressing various problems of connecting mechanically dissimilar parts and coming up with interesting solutions such as self-healing materials that could help solving issues with composite fatigue behaviour. One part of this Call is to assess the feasibility of such solutions and their potential in commercial products.

The reference aircraft is a full-metal aircraft with a composite nose part of the fuselage (CNP) which is the only primary structure made of composite (carbon fibre reinforced polymer – CFRP) – see Figure 13. Apart from the CNP, there is a wide range of other composite parts connected to the metallic fuselage such as a landing gear nacelle, doors, engine cowling, various streamline fairings etc.

Since the composite nose part of the fuselage falls within the direct strike zone with high possibility of a lightning strike attachment to the aircraft structure and there are several vital instruments located inside the structure, this Call aims also on optimization of the electromagnetic properties of the joints. As the CNP is where most of the structural metal-composite hybrid joints can be found it was chosen to serve as the reference demonstrator for implementation of innovative joining methods.

Both CNP demonstrators (reference + innovative) will be provided for final testing and evaluation of innovated joints' performance by the Topic Leader. Final testing of the demonstrators is out of scope of this Call.

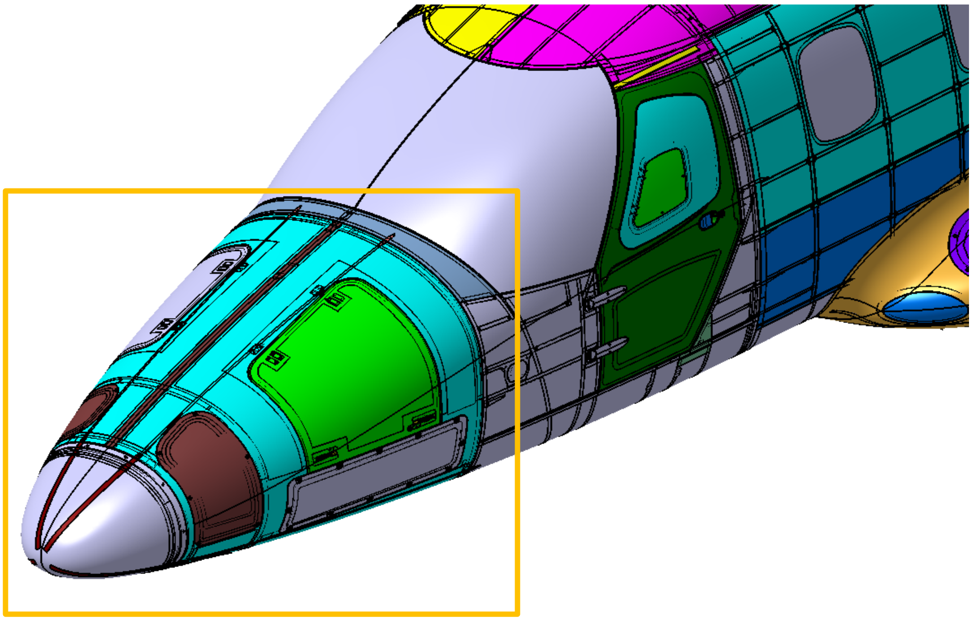


Figure 13: Composite nose part (CNP) of the fuselage of the EV-55 aircraft

2. Scope of work

- **Optimization and improvement of electromagnetic (EMC) properties of CNP joints**
  - Development of manufacturing technology and methodology for innovative joints.
  - Joints can be completely re-designed or optimized with application of different (but appropriate) standard methods such as bonding, welding etc. or new innovative joining methods developed recently.
  - Strength of innovative joints should be at the same level or better and costs reasonably preserved.

- **Gathering of strength test data of CNP joints for development of sizing methodology**

- Development of sizing methodology is out of scope of this Call.

All joints that are currently used on the CNP are categorized in the Table 1.
At the beginning of the project the Topic Manager will support applicant with relevant information about these joints such as their current manufacturing procedure, means of protection and application on the aircraft structure etc. together with 3D CAD model of whole reference demonstrator.
The applicant shall provide appropriate EMC and strength tests of reference joint specimens (task T2), on the basis of the research study performed under task T1 in order to review the current state-of-art and assess potential means of improving the joints. Then, upon mutual agreement between applicant and Topic Manager, the final number and types of joints to be examined and optimized will be decided, together with a revision of a scope of all possible innovative activities related with them. The outcomes shall be summarized in a feasibility study that is scheduled as deliverable.
In the following step (task T3), the specimens of all the chosen joints will be re-designed according to developed innovative production technology or optimized ones. It will be followed by their production and thorough testing and evaluation (task T4).
To assess the behaviour and applicability of the optimized joints in the overall structure, the applicant shall prove that innovative joints can be implemented into the CNP demonstrator (task T5). The testing of the demonstrator itself is out of scope of this Call. However, the innovative joints will be integrated into the structure according to the instructions delivered in tasks T5 and T6, so some level of cooperation with the applicant is expected.
In the final stage (task T6), the manufacturing methodologies for developed innovative joining concepts will be summarized in deliverable report with respect to all relevant aspects mentioned in Section 0.

Simultaneously, computational models describing mechanical and electrical properties of reference and innovative joints will be created by Topic Manager and continuously improved in cooperation with the applicant that will provide the test results. These models and test results will be served as the base for the development of the sizing methodology of hybrid joints. This sizing methodology is out of scope of the Call.

All subsequent logical steps are described in greater detail in Section 0.

The aim of the project is to modify selected joints either by <u>implementing new technologies</u> identified in the initial task T1 or by <u>optimizing the current state</u> of joints to provide better strength-to-weight ratio and exert satisfactory electromagnetic behaviour while preserving reasonable costs.

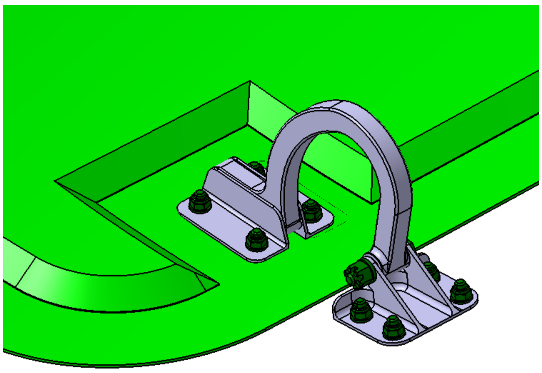
In the table on next page, a categorization of joints that can be found on the CNP is given. Note that only typical representatives of respective joint types are given here. There are usually several other structural joints of similar appearance differing e.g. by bolt pitch or laminate stacking. The expected number of joints falling within the respective categories that will be investigated are given in the column “Estimated no. of investigated joints**”.** These joint counts are not binding though and may change in the future based on the research and initial analyses. However, the total amount of joints to be investigated will not exceed 15 joints.

ID	Name	Estimated no. of investigated joints	Connection type	Joint type	Purpose	Composite type	Part of	Reference
1	hinge to door/cover	2	permanent	bolted	Strength, LPS	shell	-	Figure 14 (A)
2	hinge to door/cover through honeycomb	2	permanent	bolted	Strength, LPS	honeycomb	-	Figure 14 (B)
3	hinge to shear-wall	1	permanent	bolted, bonded	Strength, LPS	shell	-	Figure 15 (A)
4	riveted joint (nuts)	1	removable	bolt + riveted nuts	LSP, HIRF, EnP	shell	-	Figure 15 (B)
5	door to cover	1	removable	Camloc	LSP, HIRF, EnP	shell	-	Figure 16
6	riveted joint	1	permanent	riveted	Strength, LPS, EnP	shell	-	Figure 17 (A)
-	*metallic mesh to miscellaneous metallic parts of a joint*	4*	permanent	bonded, riveted	LPS, HIRF	shell, honeycomb	1,2,3,4, 5,6	-
-	*Integrated metallic LPS strip to miscellaneous parts of a joint*	3*	permanent, removable	bolted, riveted, bonded	LPS	shell, honeycomb	1,2,3,4, 5,6	Figure 17 (B)

*Not considered as a stand-alone joint

Table 1: Overview of metal-composite hybrid joints located on the CNP

LPS .... Lightning Protection System
HIRF .... High Intensity Radiated Field
Strength .... load carrying member
EnP .... Protection against environmental influence
Utility .... auxiliary structure (various bracket and instrument attachment – to minimize deterioration of composite properties)



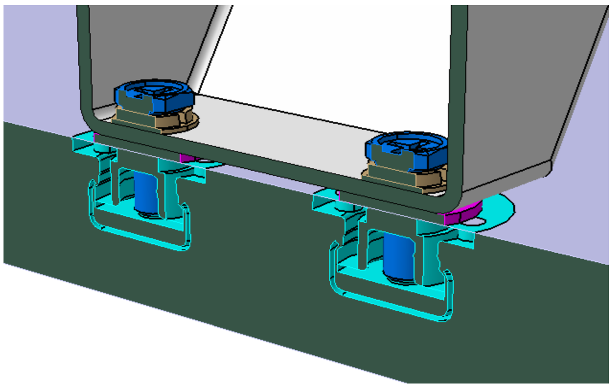
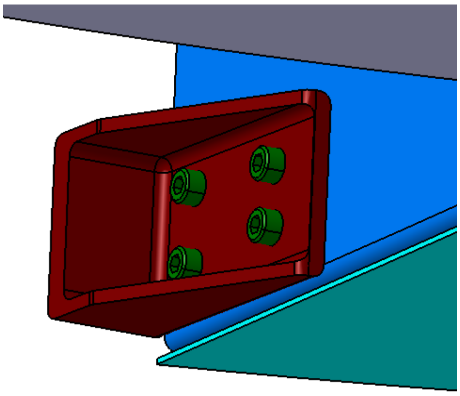


Figure 14: (A) Bolted joint of a hinge to door/cover (B) Hinge to door/cover through honeycomb



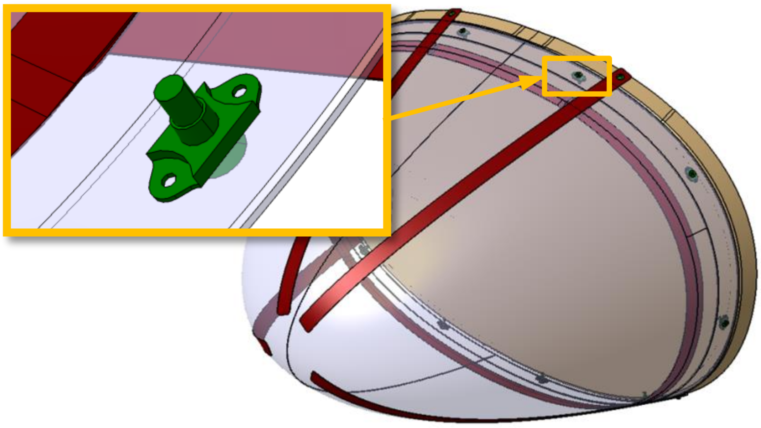
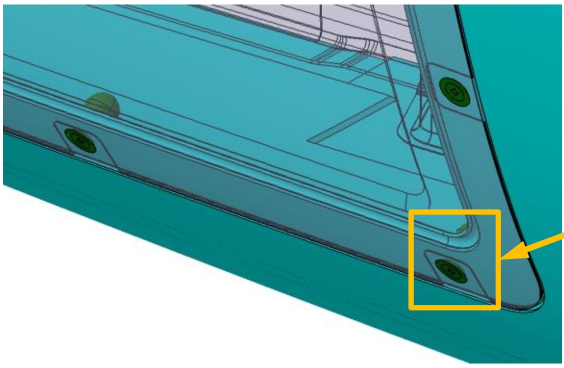


Figure 15: (A) Combined bolted/bonded hinge to shear-wall (B) Joint with riveted nuts



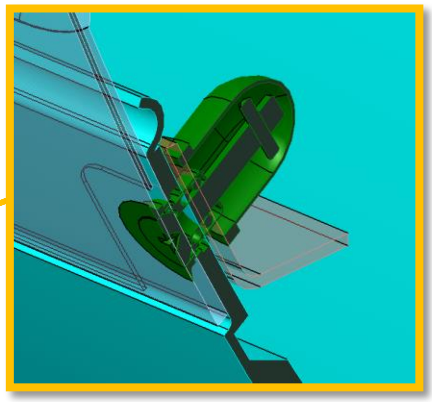
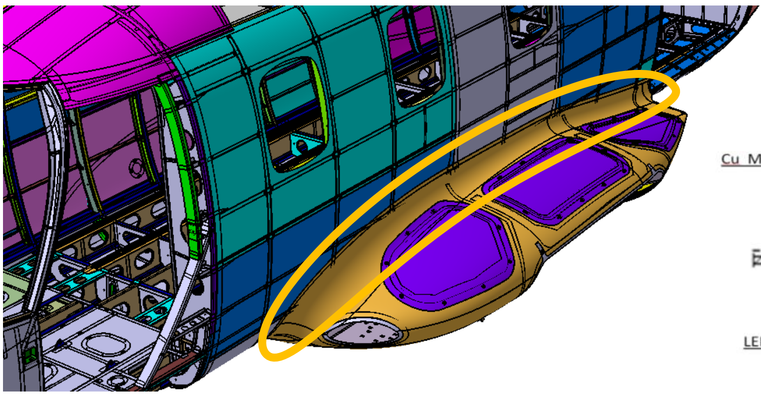


Figure 16: Bolted joint – Camloc



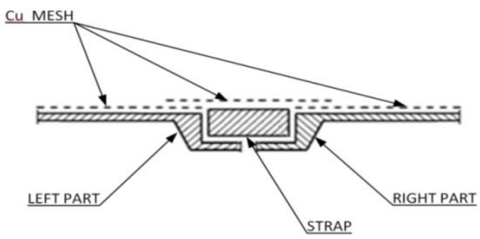


Figure 17: (A) General riveted hybrid joint (B) Cu mesh to lightning strap attachment

Regulation Requirements

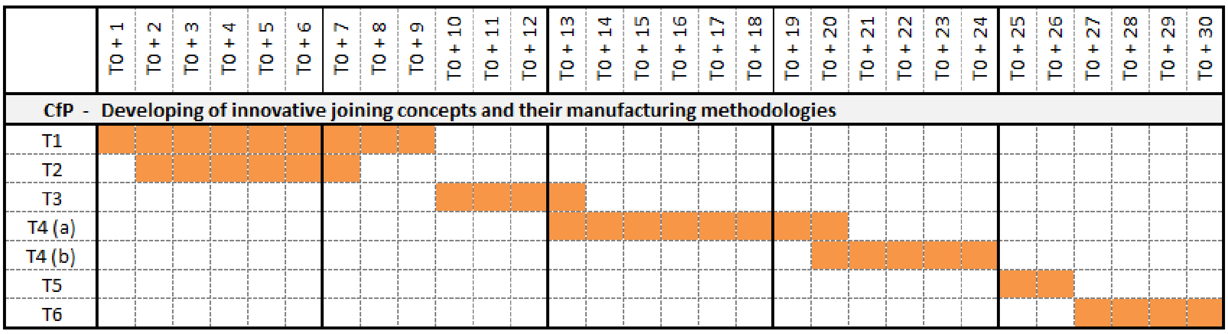
A short summary of the requirements of CS-23 Regulation is given hereafter:

- Static strength
  - §23.303, §23.305, §23.307
- In case of primary structure, fatigue coupon test + residual strength test may be required
  - §23.573
- Lightning strikes, HIRF
  - §23.863, §23.867

Work-Plan and Time Schedule

An indicative work-plan as well as a short description of tasks to be performed is provided below.

Tasks		
Ref. No.	**Title – Description**	**Due Date**
T1	Feasibility study of joint optimization	T0 + 9 months
T2	Reference specimens: Design, production, testing and evaluation	T0 + 7 months
T3	Design of innovative specimens and development of production technology	T0 + 13 months
T4 (a) T4 (b)	Innovative specimens: production, testing and evaluation Innovative specimens: 2nd round (if necessary)	T0 + 20 months T0 + 24 months
T5	Validation of innovative joints for application into demonstrator	T0 + 26 months
T6	Development of manufacturing methodology for innovative joining	T0 + 30 months



N.B.: Planning to be adapted to effective start of the project.

T1 - Feasibility study of joint optimization

Extensive research study shall be performed to review current state-of-art and assess all potential means of improving the CNP joints mentioned in this Call. These joints can be completely re-designed or optimized with application of different (but appropriate) standard methods such as bonding, welding, interlocking etc. or new innovative joining methods developed recently.

Simultaneously task T2 will be performed.

Outcomes of research study and test results of T2 shall lead to mutual agreement of the scope and types of joints to be examined and optimized. Feasibility study with considerations of optimization and production concepts for chosen joints will be compiled.

T2 - Reference specimens: design, production, testing and evaluation

Simultaneously with task T1, specimens of reference CNP joints shall be designed and produced for testing. Corresponding specifications for mechanical and electromagnetic tests shall be compiled and followed by tests and test result processing. The obtained data are essential for the decision making process at the end of task T1.

CAD models and test results of reference specimens shall be provided to the Topic Manager for development and validation of reference numerical models.

T3 - Design of innovative specimens and development of production technology

The joint specimens employing the innovative technologies shall be designed according to feasibility study compiled in task T1 and the report describing the technology of production together with its pitfalls shall be compiled.

Final CAD models of specimens shall be provided to the Topic Manager for development of innovative numerical models.

T4 - Innovative specimens: production, testing and evaluation

At this stage, the innovative specimens shall be produced, tested and the results processed. If necessary, changes shall be applied to the specimens and a second batch of specimens shall be produced and tested.

Test results shall be provided to the Topic Manager for comparison and validation of numerical models.

T5 - Validation of innovative joints for application into demonstrator

A study assessing the possibilities of optimized joints integration into the demonstrator shall be performed in this stage. The aim of the study is to provide solutions for design and technology modifications in order to facilitate the integration of novel joints into the demonstrator structure.

Summary and general evaluation of test data shall be compiled in this stage.

T6 - Development of manufacturing methodology for innovative joining

The final step of the project is to develop the manufacturing methodology for innovative joints regarding the preparation of the parts, production, demands on environmental properties, necessary tools, manipulation and storage limitations etc. In addition, the means of protection against deterioration in service shall be provided and the program for quality control developed.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Report: test specification of reference specimens Report: test methodology	R R	T0 + 4
D2	Test results of reference specimens	D / R	T0 + 7
D3	Feasibility study of joint optimization	R	T0 + 9
D4	CAD data of innovative joints Description of production technology of innovative joints	D R	T0 + 13
D5	Test results of innovative specimens (1st round) *Test results of innovative specimens (2nd round) if needed*	D / R D / R	T0 + 18 T0 + 24
D6	Validation of innovative joints for application into demonstrator	R	T0 + 26
D7	Report on innovative joining methodology	R	T0 + 30

*Type:
R: Report
D: Data delivery (test results, CAD models)

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Final selection of joints for optimization and decision on scope of specimens to be tested	RM	T0+9
M2	Specimens of innovative joints are produced	R	T0+16
M3	Approval of means of integrating innovative joints into demonstrator structure	RM	T0+26

*Type:
R: Report
RM: Review Meeting

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

- Access to testing and production facility necessary for preliminary evaluation of the joint concepts
  - Tensile, bending, impact tests;
  - Fatigue testing;
  - Evaluation of impedance / transfer parameters of a joint (electrical behaviour);
  - Experimental assessment of joint thermal behaviour caused by passing electric currents;
  - Shielding effectiveness measurement (simple test samples: multiple joints ordered in a row, etc.).
- Experience in
  - Design and development of composite materials and joints;
  - Analytical and numerical analyses (stress, fatigue, thermal, electromagnetic field);
  - Design and development of adhesive and protective materials (glues, corrosion resistant coatings).

XII. Hardware demonstrator development and deployment on Future Industrial Human Machine Interface (HMI) and Connected factory technologies.

Type of action (RIA or IA)	RIA		
Programme Area	AIR – WP B-3.6		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	300 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	30 months	**Indicative Start Date**[41]	Q2 2017

Identification	Title
JTI-CS2-2016-CFP04-AIR-02-34	**Hardware demonstrator development and deployment on Future Industrial Human Machine Interface (HMI) and Connected factory technologies.**
Short description (3 lines)	
The objective is to develop the infrastructure, hardware and software regarding future HMI (for "free-hands" assembly processes) and connected factory technologies (interconnection of separate systems in a unique information workflow). This will help to reduce manufacturing cost and to increase automation and flexibility in assembly process developing novel and advanced techniques.	

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

1. Background

In the current times and within other factors, the relentless increase of competitiveness of the manufacturing processes is becoming a mandatory key point to prevail in the sector. One important aspect with a lot of room for improvement is the flexibility and agility of the current assembly process.

Nowadays, it is a fact that these processes are not taking advantage of the existing technologies, very spread in the other hand in the domestic world regarding topics like: persons and means localization (google earth, GPS Google Sky), wireless connection, unique data database, remote voice video communications, augmented reality, voice and gesture device control applications, voice recognition, biometric monitoring sensorization in portable devices, including headset and glasses and Integration of applications.

This apparent reluctance against the inclusion of these very useful technologies in the aeronautical plants and its processes can be explained by considering the peculiarities of the aeronautical manufacturing environment:

- Work in environments with structures that attenuate signals commonly used for data connections.
- Existence of a large number of tools with a low level of automation and low or non-capacities of connection to data networks.
- High security restrictions for tools networks connection from IT Security department.

It is envisaged that the inclusion of these technologies in the industrial aeronautical manufacturing environment will release the worker from non-added-value tasks as well as in addition allowing remote support to the assembly processes, quick attestation, and contributing to full paperless, with the consequence that aeronautical manufacturing processes will become much more competitive

2. Scope of work

The activities to be performed can be organised in two main work packages.

Work package 1. - Hardware definition and development for HMI in productive environments

Currently in the normal aeronautical manufacturing assembly process, there is no solid customized set of integrated technologies to localize/navigate persons and tools and parts within a typical shop floor in and out the structures, connect worker's mobile devices and tooling to the network acquiring data and integrating this data on line with the rest of the manufacturing process live data.

The aim is the integration on a manufacturing real environment of CAD-CAM technologies over Portable devices including headset and glasses, remote voice-video communications, augmented reality, voice and gesture device control applications, voice recognition, biometric monitoring sensorization.

This result will be implemented as a demonstrator in a typical Final Assembly Line (FAL) assembly process selected according to the project inherent constraints.

The activities to be performed by the selected partner are as follows:

- Solution definition. Hardware selection, development needs definition and solution design. This activity shall propose a hardware solution needs development and design to deliver the objective of getting a prototype in which new HMI technologies are used. This solution will be based on the design proposed by the Topic Manager.
- Infrastructure development. To develop the necessary infrastructure to support the final prototype, in which new HMI technologies are used.
- Hardware development. To develop the hardware platform needed to support the final prototype, in which new HMI technologies are used.
- Validation and demonstrations in selected scenarios. Implementation and documentation of the necessary tests to validate the prototype, in which new HMI technologies are used.

Work package 2. - CONNECTED FACTORY: Hardware definition and development for removing paper information in order to implement remote support.

Nowadays, it is a fact that these processes are not taking advantage of the existing technologies, very extended in the other hand, in the domestic world regarding topics like persons and means localization (google earth, GPS Google Sky), wireless connection, unique data database, and Integration of applications.

This project aims,

- An integrated solution for the wireless interconnection of portable devices and tools with the capability of accurate indoor localization and navigation.
- The solution will be fully integrated of acquired data into the production system.
- This solution must be secure, regarding the access to the information, and safe, regarding the users.

It will be implemented as a demonstrator in a typical F.A.L. assembly process selected according to the project inherent constraints.

The activities to be performed by the selected partner are as follows:

- Solution definition. Hardware selection, development needs definition and solution design. This activity shall propose a hardware solution, needs development and design to deliver a prototype in which new technologies associated with the "internet of things" is used. This solution will be based on the design proposed by the Topic Manager.
- Infrastructure development. Develop the necessary infrastructure to support the final prototype, in which new technologies associated with the "internet of things" is used.
- Hardware development. Develop the hardware platform needed to support the final

prototype, in which new technologies associated with the "internet of things" is used.
- Validation and demonstrations in selected scenarios. Implementation and documentation of the necessary tests to validate the prototype, in which new technologies associated with the "internet of things" is used.

3. Major deliverables/ Milestones and schedule (estimate)

In summary, the involvement of the "Beneficiary" of this CfP will be the development of the deliverables in next tables:

Deliverables WP1			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1.1	Hardware selection, development needs definition and design for HMI.	Report	M0+17 months
D1.2	Infrastructure development and deployment for HMI	Prototype	T0+20 months
D1.3	Hardware development and deployment for HMI	Prototype	T0+23 months
D1.4	Validation and test in selected scenarios for HMI	Report	T0+30 months

Deliverables WP2			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D2.1	Hardware selection, development needs definition and design for "Internet of Things".	Report	T0+17 months
D2.2	Infrastructure development and deployment for "Internet of Things".	Prototype	T0+20 months
D2.3	Hardware development and deployment for "Internet of Things".	Prototype	T0+23 months
D2.4	Validation and test in selected scenarios for "Internet of Things".	Report	T0+30 months
D2.5	Final Report and Conclusions for "Internet of Things".	Report	T0+30 months

The applicant will work in close cooperation with the Topic Manager who will provide the adequate information and models. Further innovations and improvements and recommendations from specific studies and analysis proposed by the applicant will be welcomed.

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

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

- Verifiable experience in developing software.
- Experience in industrial projects. Knowledge of manufacturing engineering activities.
- Experience in real time localization of persons tools and manufacturing means anywhere within the plant.
- Experience in Aided Navigation for tools parts localization.
- Experience in solid and secure connection of mobile/portable devices, tools and means to the network.
- Experience in relevant data acquisition and integration in the manufacturing/logistics systems
- Experience in paperless, fully updated documentation.
- Experience in minimal non- added value movement and displacements.
- Experience in Full Remote online support.
- Experience in biometric on line attestation.

XIII. Development and deployment of new procedures and PLM Tools for A/C Ground Functional testing with Eco-design criteria

Type of action (RIA or IA)	RIA		
Programme Area	AIR – WP B-3.6		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	650 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	26 months	**Indicative Start Date**[42]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-AIR-02-35	**Development and deployment of new procedures and PLM Tools for A/C Ground Functional testing with Eco-design criteria**
Short description (3 lines)	
The objective of the Call is to develop Ground Test processes automation, from design to manufacturing stages, based on automated test systems, through Digital Mock-up, involving A/C equipment-embedded software, PLM tools (intelligent iDMU according to Eco-design criteria) and other corporate tools. This novel and advanced way to realise Ground Test, increases quality control and flexibility beside reducing manufacturing cost. All those advantages shall be confirmed using these new process and capabilities in demonstrators of AIR ITD.	

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

1. Background

The framework of this topic is the Clean Sky 2 Airframe *Work Package 3.6: "New Materials and Manufacturing Technologies.* In particular this topic deals with on-ground testing technologies applicable to airframes which are directly linked to works done by the Topic Manager and Core partner and Partners.

The objective of the Call is to develop software and hardware for the Ground Test processes automation, from design to manufacturing stages, based on automated test systems and eco criteria, through Digital Mock-up, involving A/C equipment-embedded software and other corporate tools. This novel and advanced way to perform Ground Test, increases quality control and flexibility besides reducing manufacturing cost. All those advantages shall be confirmed using these new process and capabilities in demonstrators of AIR ITD.

During the previous decade Product Lifecycle Management (PLM) concept and tools were developed as new configuration systems. However they were only focused and applied on the product and its transformation, but not on the Functional Tests and eco criteria.

On one hand, with the purpose of preventing emissions, reducing waste and energy, this project is taking the step toward eco-efficient aerospace assembly processes. These three elements, acting together, will be the main line to be followed:

- The set of parameters that impact in an eco-efficient aerospace assembly.
- The platform where the impact will be analyzed: PLM platform.
- The simulation in a 3D virtual environment where the assembly process will take place before they are implemented in a real environment (shop-floor).

On the other hand, development and consolidation of Functional Test PLM concepts, based on a concurrence of processes, methods, tools, networks, will allow optimizing and strengthening development process, industrialization and support, being the necessary base for new concurrence engineering in Functional Test.

Having in mind that A/C computers are designed by different suppliers, there is no standardization in terms of test software development and protocols definition, which leads to difficulties while carrying out integration with ground test systems. The end of this process is to find an industrial standard solution for all the A/C functional tests.

2. Scope of work

The activities to be performed can be organized in three main activities, as follows:

Activity 1.- ECO-Efficient assembly processes.

The scope here is to define which parameters are relevant when designing assembly processes to decide how they are impacted by efficiency in terms of energy and resources used.
An activity to find out the relevant parameters and how to measure and compare them vs current ways of developing assembly processes, will be carried out by the Topic manager. As a result of the previous activities, a report with functional and technical requirements will be the main input of the work to be performed by applicant.

The proposed way for developing the activities is in two phases.

- Phase one shall determine a first definition of the model and its prototype. As a result of the tests carried out from this first approximation, a deeper knowledge of the influence of the eco-efficient parameters shall be developed and as a consequence.
- The second phase of the project shall develop the final model.

Partners in this project will provide mostly the requirements, use cases and data needed for the analysis of an assembly to become more eco-efficient, while the applicant will cover the areas that are not partner business core: the software development.

The following table summarizes the activities to be performed by the selected company from the call for proposal:

Activity 1 - Work Packages CfP			
	Title - Description	***Responsible***	***Due Date***
WP1 <u>Model Definition</u>	Model first estimation for development using first version of technical and functional requirements.)	Partner	M0+5
WP2 <u>Model Validation</u>	WP 2.1 Development of a first version of the model using PLM tools for validation of energy efficiency process planning modelling.	Partner	M0+8
	WP 2.2 Development of last version of the model using PLM tools for validation of energy efficiency process planning modelling	Partner	M0+21

To clarify the proposed of each work package, the following explanations are included:

- <u>WP 1. Model Definition</u>

The purpose of this task is to establish the foundation to support a clean and sustainable production for assembly processes by the definition of a model. This model will be based on the conclusions from tasks previously developed by the partners (functional and technical requirements) in this project and will be the main input for the development of the model to be built.
The model definition will propose a framework that will serve as a platform for the development and validation, an architecture to support it, PLM tools needed and the methodology to comply with the functional requirements.

Subtasks to be carried out by the applicant:

- Architecture to support the project. A definition of the platform which will hold the model to be tested. It is expected to choose a 3D environment for the simulation. The idea is to develop the process assemblies in a 3D environment, while depending on the resources or assembly technology, the model will reflect how it will be impacted from the ecoefficient point of view.
- Information technology architecture will be proposed to support this project in conjunction with Topic Manager requirements.
- 3D environment to simulate the effects of the parameters
- Technical definition of the model. This task will develop the complete model technical definition. It will contain every technical requirement and the best way to be developed when building the model.

- <u>WP2. Model Validation</u>

The target for this task is to develop and validate the model proposed before, based on a PLM platform and tools.

The applicant will support the Topic Manager with the expertise in development under PLM platforms. The research on eco-efficiency will be validated by developing a model where the main environmental and economical parameters can be evaluated and tested. To analyze the impact on eco-efficiency, a set of KPIs will be provided that will help the process engineer to decide which design is the most beneficial (on costs and environmental impact).

The activities to be performed in this task by the applicant are:

- *<u>WP 2.1</u> Development of a first version of the model using PLM tools for validation of energy efficiency process planning modelling.*

  The activities included in this subtask are:
  - Development of the model in a 3D environment, with PLM tools (to be decided by the Topic Manager during the functional and requirements phase). Study of the different alternatives to implement the model.
  - This model will contain all the requirements coming from task 1, thus it will be the first approximation to test. This represents an early model with a set of parameters that shows that the eco-efficiency in assembly processes can be used to help the engineer to evaluate the best process.
  - This task will be developed entirely by the applicant.

- *<u>Subtask 2.2</u> Development of last version of the model using PLM tools for validation of energy efficiency process planning modelling.*

  This is the second phase for the development of the model with a refined set of requirements and parameters coming from the task 1. This task will be developed entirely by the applicant.

Activity 2.- Integration of testing systems on i-DMU

This activity aims to develop processes, methods and tools in order to apply the concept of the new concurrent engineering in the field of On Ground A/C functional tests as a solution of the outstanding problems of the On Ground A/C Functional Tests, described above.

Moreover, the objective of this activity is also to implement a RFLP (Requirement, Functional, Logical, Physical) system where the requirements of the systems is integrated with the product. RFLP paradigm enables to define a system based on its fundamentals aspects or facets through essential views and their relations:

- The Requirements and Tests View (R) defines needs and requirements
- The Functional View (F) defines what the system does: Operational (Intended use) and Functional (Internal/Technical).
- The Logical View or architecture View defines how the system is implemented,
- The Physical View defines a virtual definition of the real world product.

The integration with PLM tools platform implies at least to ensure the traceability with engineering data, supported by the link with the PLM model or its storage as "document". This integration shall offer the capability to open the data from the PLM platform.

How to do that:

- Strengthen the interfaces manufacturing offices with design offices
- Automation of test means, tools, process and methods
- Standarization of the information related with design requirements, processes and methods
- Dissemination of automation standards throughout the different stages of the process
- Process allowing interconnection of all the actors
- Process test data through data-mining techniques
- Development of new technologies to improve the interaction between users inside A/C during test process.
- Advance of eco-solutions: miniaturization of resources needed during a test process.

The following table summarizes the activities to be performed by the selected company from the call for proposal:

Activity 2 - Work Packages CfP			
Title - Description		***Responsible***	***Due Date***
WP1 GT PLM. Orientation, design and industrialization by requirements	Orientation capacity analysis for the requirements of actuals NTs/GTRs and GTIs/PFs. Needs identification	Partner	M0 + 11
WP2 GT PLM. Tools integration	Concurrence for Model development and establishment	Partner	M0 + 17
WP3 GT PLM & iDMU implementation	Development and deployment of selected solution in CATS	Partner	M0 + 20

Activity 2 - Work Packages CfP			
Title - Description		***Responsible***	***Due Date***
WP4 System test visualization in DMU.	WP 4.1-Alternatives for the test process representation in the model (iDMU)	Partner	M0 + 17
	WP 4.2-Design of solution for CATS visual interface to improve troubleshooting	Partner	M0 + 17
	WP 4.3-Development and deployment of selected solution in CATS	Partner	M0 + 17

To clarify the proposed of each work package, the following explanations are included:

- WP 1 - Needs assessment to transform current NTs/GTRs and PFs/GTIs to NTs/GTRs and PFs/GTIs oriented to requirements.
- WP 2 - Process definition of Model development from functional test requirement to iDMU.
- WP 3 - Development and deployment of selected solution in CATS, to improve the PLM and the contributions of the current testing system for collaborative engineering.
- WP 4.1- Alternatives for the test process representation in the model (iDMU). Study of alternatives for the test process representation in the selected tool to improve collaborative engineering.
- WP 4.2- Design of solution for CATS visual interface to improve troubleshooting. Design of solution to make system information available in actual test system (CATS), to improve troubleshooting.
- WP 4.3- Development and deployment of selected solution in CATS. Development and deployment of the selected solution for make system information available in actual test system (CATS), to improve troubleshooting.

<u>Activity 3.- Automated Aircraft (A/C) Testing Technologies.</u>

The main objective of this line is the definition of standard solutions for developing test software into A/C computers, in addition to the utilization of a standard communication protocol to communicate and control de test software from external ground test equipment. In order to develop and demonstrate the solution feasibility, the objective is to integrate this solution in one computer installed on on-ground wing demonstrator of Clean Sky II project.

Moreover, once a standard solution will be defined, the use of on-board test SW will be supported and extended to new aeronautical programs or even already existing ones, after business case studies will demonstrate that economic objectives are met by making use of on-board test software.

Developing the solution consists in:

- Studying the test requirements that need to be covered by the utilization of on-board test software.

- Establishing common rules for the development of on-board test software in terms of coding, resources utilization, and scope of utilization.
- Defining a standard communication protocol for controlling the on-board test software from ground test equipment.
- Foster auto-testing technologies into A/C Computers.
- Verifying the solution after implementation.

The following table summarizes the activities to be performed by the selected company from the call for proposal:

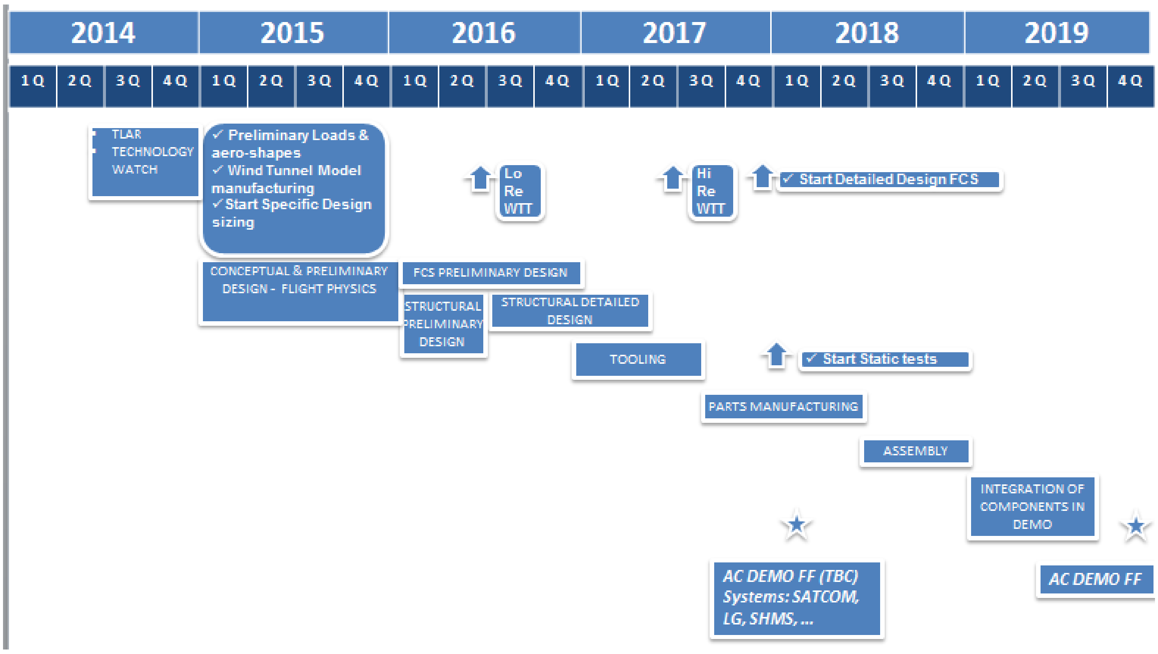
Activity 3 - Work Packages CfP			
Title - Description		***Responsible***	***Due Date***
WP 1. Extended use of test-software for self-testing aircrafts	WP 1.1- Research into aircraft systems where the development of SW test supposes an optimal solution for the testing in FAL: advantages and solved problems	Partner	M0 + 5
	WP 1.2- Conclusions report	Partner	M0 + 17
	WP 1.3-Development/implementation of CATS communication interface	Partner	M0 + 17
	WP 1.4-Prototype development	Partner	M0 + 14
WP 2. Technologies (artificial vision, robotics) for aided interaction with cockpit	Prototype development	Partner	M0 + 26

To clarify the proposed of each work package, the following explanations are included:

- WP 1.1- Research into aircraft systems where the development of SW test supposes an optimal solution for the testing in FAL: advantages and solved problems
- WP 1.2- Conclusions report. Conclusions report on standard's definition and development of test-software for self-testing aircrafts.
- WP 1.3 - Development/implementation of CATS communication interface to test-software for self-testing aircrafts prototype.
- WP 1.4 - Prototype development. Prototype development of hardware where the test-software for self-testing aircrafts is included.
- WP 2 - Prototype development. Prototype development for aided interaction with cockpit using new technologies (artificial vision, robotics…).

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 involvement of the "Beneficiary" of this CfP will be the development of the deliverables shown in the next table.

Deliverables Activity 1			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1.1	Model first estimation for development using first version of technical and functional requirements.	Report	M0+5
D1.2	Development of a first version of the model using PLM tools for validation of energy efficiency process planning modeling.	Report, Skill Transfer, Demonstrator	M0+8
D1.3	Development of last version of the model using PLM tools for validation of energy efficiency process planning modeling.	Report, Skill Transfer, Demonstrator	M0+21

Deliverables Activity 2			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D2.1	Orientation capacity analysis for the requirements of actuals NTs/GTRs and GTIs/PFs. Needs identification	Report	M0+11
D2.2	Concurrence for Model development and establishment	Report	M0+17
D2.3	Development and deployment of selected solution in CATS	Report and Prototype	M0+20
D2.4	Alternatives for the test process representation in the model (iDMU)	Report	M0+17
D2.5	Design of solution for CATS visual interface to improve troubleshooting	Report	M0+17
D2.6	Development and deployment of selected solution in CATS	Report and Prototype	M0+17

Deliverables Activity 3			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D3.1	Research into aircraft systems where the development of SW test supposes an optimal solution for the testing in FAL: advantages and solved problems	Report	M0+5
D3.2	Extended use of test-software for self-testing aircrafts - Conclusions report	Report	M0+17
D3.3	Development/implementation of CATS communication interface	Report and Prototype	M0+17
D3.4	Extended use of test-software for self-testing aircrafts - Prototype development	Report and Prototype	M0+14
D3.5	Technologies (artificial vision, robotics) for aided interaction with cockpit - Prototype development	Report and Prototype	M0+26

The applicant will work in close cooperation with the Topic Manager who will provide the adequate information and models. Further innovations and improvements and recommendations from specific studies and analisys proposed by the applicant will be welcomed.

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

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

For all those activities, the applicant is required to have deep knowledge in aircraft ground test processes, GTR (Ground Test Requirement) and GTI (Ground Test Instruction) processes, GTI configuration control, requirement management tool DOORs, verifiable CATS (Computer Aided Test System) knowledge at user and CATIA V5 and V6 customization with capability to develop new functionalities. The applicant will also be required to have, additionally to that, deep knowledge of i-DMU and CATIA at programing level and of the different aircraft configuration control techniques.

In addition, the applicant will be required to have verifiable experience in developing SW and in the engineering and manufacturing of test means in the aerospace sector, and experience in projects related to sustainability manufacturing.

Moreover, it should have the following tools and knowledge that could hold the work to be carried out:

- Basic information technology architecture.
- CATIA V5 and CATIA V6 platform software licenses for developers

For the development of airborne test software for computers is required to have extensive experience in development and verification of software certifiable according to standard DO-178.

5. Abbreviations

A/C: Aircraft
AIM: Aircraft Interface Module
CAD/CAM: Computer-Aided Design and Computer-Aided Manufacturing
CATS: Computer Aided Test System
DMU: Digital Mock-Up
DIT: Dirección de Ingeniería y Tecnología (Design Office)
ERP: Enterprise Resource Planning
HMI: Human Machine Interface
GT: Ground Test
GTI: Ground Test Instruction
GTR: Ground Test Requirement
ICD: Interface Control Documents
i-DMU: Industrial DMU
NT: Technical Note
PF: Functional Test
PLM: Product Lifecycle Management

XIV. Development of prototype system based on Laser UT technology for high speed contactless no-couplant inspection of hybrid and thick composite structures

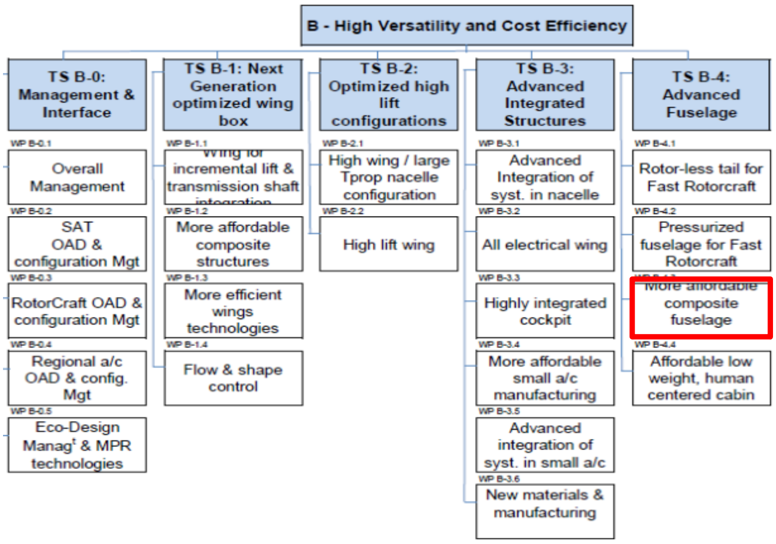
Type of action (RIA or IA)	IA		
Programme Area	AIR - WP B-4.3 – [More Affordable Composite Fuselage]		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	2 500 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	24 months	**Indicative Start Date**[43]	Q2 2017

Identification	Title
JTI-CS2-2016-CFP04-AIR-02-36	**Development of prototype system based on Laser UT technology for high speed contactless no-couplant inspection of hybrid and thick composite structures**
Short description (3 lines)	
The aim of this proposal is to develop a prototype system based on Laser UT (LUT) technology to be used for NDI inspection of hybrid composite structures, containing damping or very attenuative materials, and as well as thick laminates. This system will be used to inspect the Long Barrel Demonstrator, that will be developed in Clean Sky 2 Programme using the hybrid technology.	

[43] 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 the Clean Sky - GRA ITD Domains and in other EU projects addressed to 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 this topic is to develop a prototype system based on Laser UT (LUT) technology to be used for NDI inspection of hybrid composite structures, containing damping or very attenuative materials, and as well as thick laminates. This system will be used to inspect the Long Barrel Demonstrator, that will be developed in Clean Sky 2 Programme using the hybrid technology.

The activities can be divided into the following Tasks:

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T-01	LUT Prototype System Requirements	T0 + 2
T-02	LUT Prototype System Design	T0 + 9
T-03	LUT Prototype System Development	T0 + 22
T-04	LUT Prototype System Validation	T0 + 24

Task 01 - LUT Prototype System Requirements

The aim of this task will be to analyse Topic Manager requirements for the design and the development of LUT prototype system. To this scope the following activities shall be performed:

- Analysis of the inspection requirements, in terms of typology and location of defects to be detected, minimum detectable defect size and maximum acceptable defect size, inspection method/technique, inspection parameters, signal-to-noise ratio, etc.
- Analysis of the configuration of parts to be inspected, in terms of geometrical/dimensional features, materials and fabrication process.

These activities will be carried out in concurrence with Topic Manager specialists.

The inspection focus shall be on hybrid composite structures, containing damping materials that absorb most energy of the ultrasonic wave at 5 MHz, and as well as on laminates "thick" or made of very attenuative materials.

Final *Inspection Case* will be the Fuselage Demonstrator developed in Clean Sky 2 using hybrid materials. This Demonstrator is a fuselage section obtained by co-curing green Ω-stringers on green skin. The Fuselage demonstrator total length is about 10 m, while the diameter of external surface is about 3.5 m. Skin and Ω-stringers are made from CFRP tape and globally the thickness of the fuselage demonstrator (considering skin + stringers flanges) is in the range 1 mm -5 mm. The skin contains, in the bays limited by frames and stringers, a layer of acoustic damping material.

At the end of this task the Partner shall provide a Test Book to be used for pre and final verification and validation of LUT Prototype System. Test Book shall be approved by Topic Manager specialists.

Task 02 - LUT Prototype System Design

The aim of this task is to provide the full design for the development of LUT prototype system. This design shall implement the requirements defined in the previous task.

The system shall be able to scan a window having dimensions of 1.5m x 1.5m (at least). So the inspection of fuselage demonstrator shall be performed by consecutive fuselage translations and rotations. Considering the sizes of the fuselage barrel demonstrator, several scan windows will be necessary to cover the entire surface to be inspected. The inspection of each scan window shall be fully automatic, except for the positioning of the part.

To this scope, the following devices shall be designed:

- *High speed scanning system:* it shall be made up of a robot-based mechanics holding an optical head able to assure the coverage of each scan window, a high scanning speed (at least, 8 m^2/h) and a scanning index variable between 0.5 mm to 3 mm with 0.5 mm steps. The tolerances of mechanics for the accuracy and repeatability shall be 0.7 mm and ± 0.1 mm, respectively.
- *High peak power short-pulsed laser for generation of ultrasonic wave directly in the part (no-coupling/no-contact inspection):* it shall assure no damages of the part and the inspectability by means of Pulse Echo (PE) technique of all the areas of interest. Special care shall be taken for the inspection of hybrid composite structures, containing the layer of damping materials, and thick/very attenuative laminates. Optimal parameters of laser shall be defined to allow the inspection of these areas according to Topic Manager requirements. Spot size shall be not higher than 6 mm.
- *Detection long-pulsed laser:* it shall allow to "read" the surface displacement induced by ultrasonic wave propagation in the material.
- *Interferometer:* to demodulated the information detected by the detection laser,
- *Opto-electronic circuit*: it shall allow the detection of small signals (coming, for example, from the area with damping material) reducing the noise in order to obtain acceptable signal-to-noise ratio.
- *Acquisition module:* it shall synchronize laser shots and digitizer in order to acquire the fullwave ultrasonic signals, with a sampling frequency variable in the range 10 MHz-100 MHz with 10 MHz steps. Each sample shall be acquired at 10 bit (at least)
- *Post-processing software:* it shall be able to show and analyse the data in conventional way. In particular, A/B/C-Scan visualization, C-Scan recalculation, Statistical Analysis, Signal-to-Noise Analysis shall be possible. Moreover, specific algorithms shall be developed for the analysis of hybrid composite structures and thick/very attenuative materials.
- *Fuselage Tooling*: it shall allow to hold and manually translate/rotate the fuselage for the inspection of each scan window.
- *Layout of the LUT area*: it shall be in accordance with the applicable safety regulations for laser systems.

Task 03 - LUT Prototype System Development

The aim of this task is to develop and provide the LUT prototype system in accordance with the design coming from the previous task.

During this phase, preliminary test shall be performed at Partner factory using Topic Manager samples in order to verify the performance of each component and of whole LUT system, in terms of scanning ability and detectability of the defects. Tests to fulfil are defined in the Test Book developed in Task 1. The samples will be representative of the configuration of the structures to be inspected, in terms of geometrical/dimensional features and materials, and will contain artificial inserts simulating the types and sizes of flaws that are necessary to detect in real part.

The results of the test shall be used to optimize the key parameters of the inspection process (in particular, the generation laser, the detection chain and post-processing algorithms), to assure the correct inspectability of all the zones of interest and, in particular, of hybrid composite structures with damping materials and thick/very attenuative laminates.

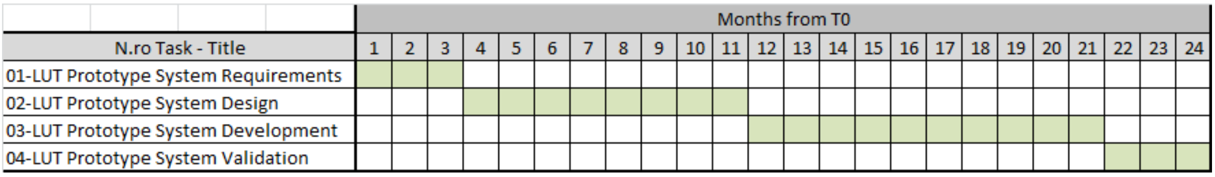
The system shall be installed at Topic Manager plant. The installation shall be performed by Partner according to the current safety regulations.

<u>Task 04 - LUT Prototype System Validation</u>

The aim of this task is the final validation of LUT prototype system developed in Task 3. To this scope all the tests foreseen by Test Book defined in Task 1 shall be fulfilled using the specific reference standards provided by Topic Manager. The inspection of these standards shall be used to verify the correct working of the whole system and identify the optimum values for each key parameter of the process, defining the final setup of the system.

Validation of LUT prototype system shall be closed with the inspection of the Fuselage Barrel demonstrator.

An estimation of activities planning is shown below:



3. <u>Major deliverables/ Milestones and schedule (estimate)</u>

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Test Book for LUT Prototype System Validation	Document	T0 + 2
D2	Design of LUT Prototype System	Document	T0 + 11
D3	Pre-validation Report	Document	T0 + 17
D4	Providing LUT Prototype System	Document/Hardware/Software	T0 + 21
D5	Validation Report	Document	T0 + 24

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Design of LUT Prototype System	Document	T0 + 11
M2	Pre-validation Report	Document	T0 + 17
M3	Providing LUT Prototype System	Document/Hardware/Software	T0 + 21
M4	Validation Report	Document	T0 + 24

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

- Proven experience in Laser UT technology applied to aeronautical structures.
- Proven experience in non-destructive inspection based on ultrasound methods applied to aeronautical structures.
- Proven experience in the realization of systems for Ultrasonic Inspection of aeronautical structures.

XV. Quilted Stratum Processes (QSP) for low cost and eco thermoplastic manufacturing of complex composite parts

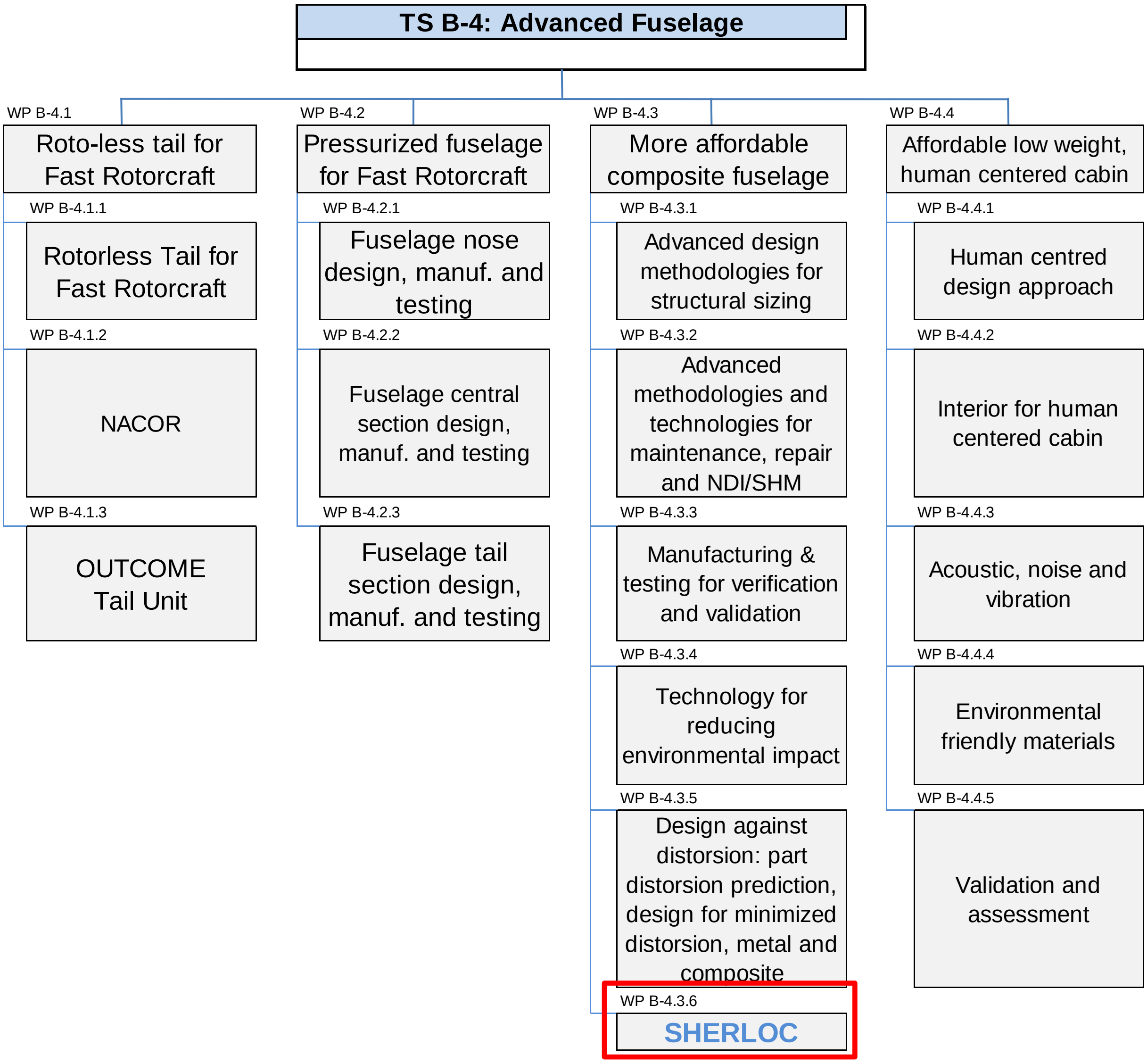
Type of action (RIA or IA)	IA		
Programme Area	AIR - WP B-4.3 – [More Affordable Composite Fuselage]		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	400 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	18 months	**Indicative Start Date**[44]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-AIR-02-37	**Quilted Stratum Processes (QSP) for low cost and eco thermoplastic manufacturing of complex composite parts**
Short description (3 lines)	
The QSP provides low material scrap, short cure cycle, competitive cost, multi-thickness part and multi-orientation part in comparison to traditional thermoplastic processes. This "no-scrap" approach is highly eco-friendly with cure cycle times in the order of a few minutes and allows multi-material assembly. This call is for the manufacture and evaluation (including an assessment of the life cycle costs) of a high quality thermoplastic window frame for a regional aircraft fuselage.	

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

1. Background

The activities in this call contribute to the Airframe ITD of Clean Sky 2 and in particular to Work Package B-4.3 "More Affordable Composite Fuselage". The flow diagram below provides an overview of the WPs within the technology stream B-4.



This call will contribute to the activities in WP B-4.3.6 SHERLOC (Structural HEalth monitoring, manufacturing and Repair technologies for Life management Of Composite fuselage). The main activities within the SHERLOC project are directed towards two main areas:

- Advanced methodologies and technologies for maintenance/repair and NDI/SHM
- Manufacturing and testing for validation and verification

In particular, the current call will contribute to design, manufacture and test of composite structures following a building block approach. The overall aim is to provide an alternative innovative manufacturing process for the SHERLOC consortium, to be assessed, alongside the manufacturing of parts done within the project, for sensorization and structural health monitoring. The overall aim should be to manufacture a part at lower possible cost and weight compared to the more traditional thermoplastic composite solutions.

2. Scope of work

Technologies, materials and processes for manufacturing of coupons, elements and sub-components will be representative of structural configuration of the new regional aircraft fuselage barrel. The aim is to drive the developed technologies towards industrialization. The driving factors (listed below) for technology and material selection include total cost reduction (manufacturing and assembly, maintenance and end-of-life), production rate increase, and automation increase in both manufacturing and assembly. The technology development will be demonstrated by a test campaign covering coupon and element. The technology should lead to manufacturing of sub-component window frames each adhesively bonded to a flat skin ready for mechanical testing by Topic Manager.

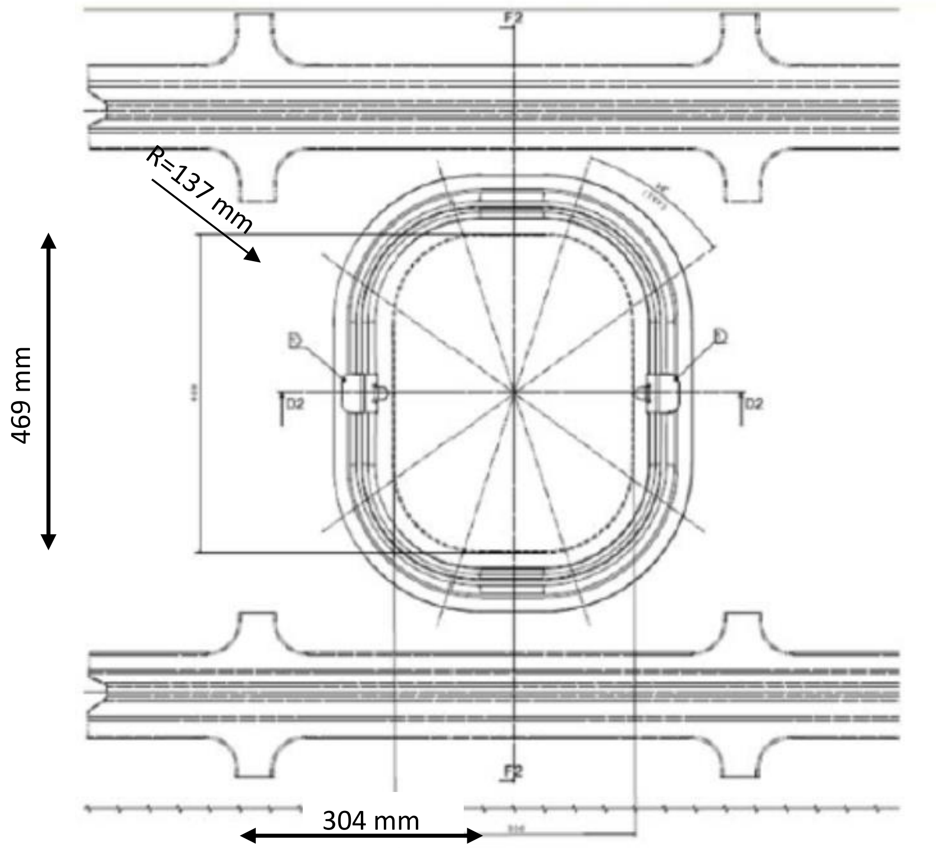
A. Design, manufacturing and testing of coupons

The first task is to design coupons in terms of material selection and layup. The baseline design of window frame with the acceptable tolerances will be provided by Topic Manager. The coupons are to be manufactured and tested for two purposes: mechanical testing and SHM testing.

- Mechanical testing of coupons (from two different batches) to obtain material parameters, material characteristics and design allowables for use in the design and optimization of the part (window frame). The tests shall evaluate the relevant stiffness, strength, fracture toughness and fatigue parameters. At least 5 replicates of each test will be required to establish mean and variability data.
- Production of 15 coupons (225 x 300 mm) with layup and thickness representative of the key element of the window frame delivered for mechanical and SHM testing by Topic Manager.

B. Design and optimization of window frames

Baseline design, including the size and geometry of the window frame, and load case scenarios will be provided by the Topic Manager. A typical geometry of a window frame for a regional aircraft is shown below.



Material paremeters and allowables obtained from the coupon tests shall be used as input to the design and optimization of the part tailored to the selected manufacturing technology. The design shall include assessment of the bonding process for attaching the window frame to a carbon-epoxy composite fuselage skin. A full assessment shall be made of the costs associated with manufacturing, maintenance and disposal at end-of-service life.

C. Manufacturing trials followed by part quality check

Manufacturing trials and quality control shall be carried out by extracting different size elements in order to characterize the manufacturing quality, part properties and repeatability. The tests shall include appropriate NDI techniques for macro-examination, micro-examination and destructive testing (porosity, fiber content and orientation). The tests shall also include a demonstration of the effectiveness of the adhesive bonding of the thermoplastic composite to a carbon-epoxy composite.

D. Manufacturing of window frames and skin

Five window frames to be manufactured with acceptable quality, adhesively bonded into flat carbon epoxy panels (~2mx2m, approximately 3mm thick) and delivered to the Topic Manager ready for testing. The Topic Manager will provide the geometry and layup of the skin panel.

E. Repair of window frames

Repair of a production defect shall be addressed. The exact nature of these defects shall be highlighted during the window frame manufacturing trials and a suitable repair procedure shall be demonstrated. Repair of cosmetic damage (e.g. dent or scratch which does not degrade the structural function) on visible surface must also be demonstrated.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T1	Design, manufacturing and testing of coupons	T0+6
T2	Design and optimization of window frames	T0+9
T3	Manufacturing trials followed by part quality check	T0+12
T4	Manufacturing of window frames bonded to a carbon epoxy skin	T0+15
T5	Repair of window frames	T0+18

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date (Months after start)***
D1	Material parameters and allowables from test	Test report	T0+6
D2	15 SHM Coupons	Hardware	T0+6
D3	Design and optimization of window frame	Report, CAD model	T0+9
D4	Manufacturing trials followed by part quality check	Test report	T0+12
D5	Manufacturing of window frames (to include assessment of production rate and life cycle costs) bonded to a carbon epoxy skin	Hardware + Report	T0+15
D6	Repair of window frames	Report and Hardware	T0+18

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date (Months after start)***
M1	Manufacturing of SHM coupons ready for test	Hardware	T0+6
M2	Successful QSP trials for elements	Report	T0+12
M3	Manufacturing of window frames bonded to a carbon epoxy skin to meet the production and mechanical requirements	Hardware	T0+15
M4	Successful repair of manufacturing defects and cosmetic damage	Report and Hardware	T0+18

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

- Proven experience of manufacturing complex parts using the thermoplastic QSP process
- Proven experience in composite product design and modelling, prototype manufacture, NDT, testing and life-scycle costing
- Track record in the application and optimisation of low cost composite manufacturing processes

5. Clean Sky 2 – Engines ITD

I. High speed turbine performance improvement through cascade tests

Type of action (RIA or IA)	RIA		
Programme Area	ENG - WP 2 – Ultra High Propulsive Efficiency		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	1500 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	18 months	**Indicative Start Date**[45]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-ENG-01-10	**High speed turbine performance improvement through cascade tests**
Short description	
Cascade tests for subsonic and transonic airfoil profiles consistent with high-speed LP turbine design. The aim of the tests is to validate and improve performance of turbine blades by testing various configurations. 'State of the art' instrumentations & facilities are required to capture unsteady phenomena that were not taken into account in the past.	

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

1. Background

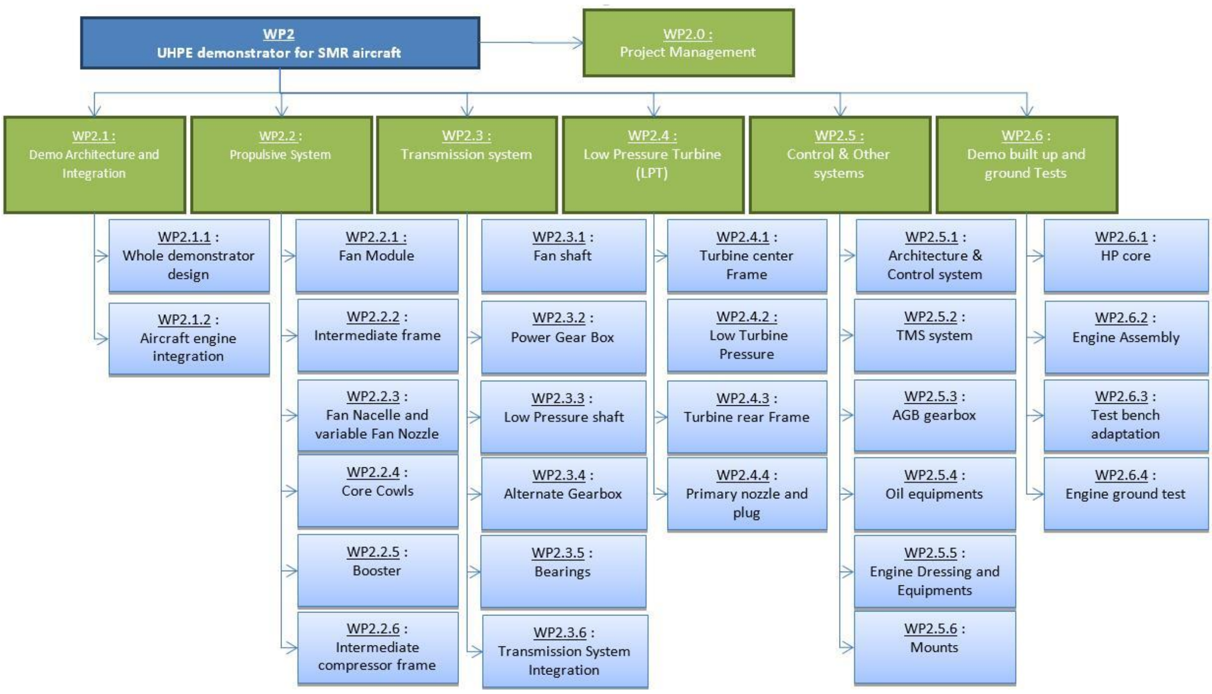
The UHPE Demonstration Project aims at designing, manufacturing & testing a Ultra High Propulsion Efficiency Engine Demonstrator. It involves most of the best European Engine & Engine Modules & Sub-systems Manufacturers.

The UHPE requires an innovative Low Pressure Turbine aerodynamic design. The aim of the present document is to present a serie of cascade tests that are needed to:

1. Validate estimated performance of LPT blades used for UHPE test engine.
2. Find optimal geometries in term of performance for this kind of application.

The installation required for that purpose, as described hereinbelow, should be specifically fitted to deal with complex phenomena such as transonic flows and shock/boundary layer interaction.

The breakdown in this WP2 is the following :



2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 0	*High Speed cascade tests – 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. **General Requirements** • The partner shall work to a certified standard process.	T0 + 18 months
Task 0.1	Snecma to provide and agree with partner overall boundaries of test conditions for the 6 configurations	T0 +1 month
Task 0.2	*Input data #1:* Snecma to provide geometries , test matrix (including inlet conditions and expected results) for test configurations #1 & #2	T0 + 2 months
Task 0.3	*Input data #2:* Snecma to provide geometries , test matrix (including inlet conditions and expected results) for test configurations #3 & #4	T0 + 10 months
Task 0.4	*Input data #3:* Snecma to provide geometries , test matrix (including inlet conditions and expected results) for test configurations #5 & #6	T0 + 14 months
Task 1.0	*Test configurations – Requirements* To provide and achieve a plan including test and capability demonstration for each technical element. Presentation by the partner of the test configuration & conditions to validate the compliance with the formulated requirements	T0 + 4 months
Task 2.1	*Test configuration #1 (Optimization of the pitch over chord ratio – part 1) – Validation and analysis of results* Presentation of the test results & analysis by the partner for the 3 geometries. Deliverable: report detailing the bench & measurement characteristics + the test results analysis	T0 + 9 months
Task 3.1	*Test configuration #2 (Optimization of the pitch over chord ratio – part 2) – Validation and analysis of results* Presentation of the test results & analysis by the partner for the 3 geometries. Deliverable: report detailing the bench & measurement characteristics + the test results analysis	T0 + 12 months

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 4.1	*Test configuration #3 (Optimization of the Mach number distribution) – Validation and analysis of results* Presentation of the test results & analysis by the partner for the 2 geometries. Deliverable: report detailing the bench & measurement characteristics + the test results analysis	T0 + 14 months
Task 5.1	*Test configuration #4 (Study of the secondary flows) – Validation and analysis of results* Presentation of the test results & analysis by the partner for the 2 geometries. Deliverable: report detailing the bench & measurement characteristics + the test results analysis	T0 + 16 months
Task 6.1	*Test configuration #5 (Impact of the trailing edge thickness) – Validation and analysis of results* Presentation of the test results & analysis by the partner. Deliverable: report detailing the bench & measurement characteristics + the test results analysis	T0 + 17 months
Task 7.1	*Test configuration #6 (Impact of the profile roughness) – Validation and analysis of results* Presentation of the test results & analysis by the partner. Deliverable: report detailing the bench & measurement characteristics + the test results analysis	T0 + 18 months

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	Presentation of configurations , tests associated (range of Mach number, Reynolds …) and instrumentation expected	M	T0
D2	Common agreement between Snecma and partner of test boundaries and instrumentation used for each configuration	M + R	T0 + 1 month
D3	Intermediate presentation by the partner of rig + instrumentation used. Demonstration of capability to perform all tests previously presented. Risk analysis.	M	T0 + 3 months
D4	Finale presentation by the partner of rig + instrumentation used. Demonstration of capability to perform all tests previously presented. Risk analysis.	M + R	T0 + 4 months
D5	Test configuration #1 – Validation of tests conditions report + risk reduction plan	M + R + HW	T0 + 4 months

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D6	Test configuration #1 –Intermediate results of test #1	M	T0 + 7.5 months
D7	Test configuration #1 – Validation and analysis of results report	M + R	T0 + 9 months
D9	Test configuration #2 – Validation of tests conditions report + risk reduction plan	M + R + HW	T0 + 9 months
D10	Test configuration #2 –Intermediate results of test #1	M	T0 + 11 months
D12	Test configuration #2 – Validation and analysis of results report	M + R	T0 + 12 months
D13	Test configuration #3 – Validation of tests conditions report + risk reduction plan	M + R + HW	T0 + 12 months
D14	Test configuration #3 –Intermediate results of test #1	M	T0 + 13 months
D16	Test configuration #3 – Validation and analysis of results report	M + R	T0 + 14 months
D17	Test configuration #4 – Validation of tests conditions report + risk reduction plan	M + R + HW	T0 + 14 months
D18	Test configuration #4 –Intermediate results of test #1	M	T0 + 15 months
D20	Test configuration #4 – Validation and analysis of results report	M + R	T0 + 16 months
D21	Test configuration #5 – Validation of tests conditions report + risk reduction plan	M + R ++ HW	T0 + 16 months
D24	Test configuration #5 – Validation and analysis of results report	M + R	T0 + 17 months
D25	Test configuration #6 – Validation of tests conditions report + risk reduction plan	M + R + HW	T0 + 17 months
D28	Test configuration #6 – Validation and analysis of results report	M + R	T0 + 18 months

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***

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

Purpose of the tests

All the following informations are given as an indication of the configurations to be tested. The test matrix expected is not frozen yet and will be precised as mentionned in section 2. For each geometry, it is expected to be tested influence of Mach number through variation of pressure ratio, Reynolds effect as well as Strouhal and incidence.

Tests description				
Parameter tested	***Description***	***Configurations***	***Number of geometrical configurations***	***influences***
Optimization of the pitch over chord ratio – part 1	Study of the impact of the pitch over chord ratio on the blades performance. The test is done for one type of airfoil profile.	• 3 configurations with modification of pitch to chord ratio • Pitch over chord ratios are between 0.60 and 1.10.	3	Mach number Reynolds Strouhal Incidence
Optimization of the pitch over chord ratio – part 2	Study of the impact of the pitch over chord ratio on the blades performance. The test is done for a second type of airfoil profile.	• 3 configurations with modification of pitch to chord ratio • Pitch over chord ratios are between 0.60 and 1.10.	3	Mach number Reynolds Strouhal Incidence
Optimization of the Mach number distribution	Study of the impact of the Mach number distribution, mainly the location of the peak, on the blade performances and secondary flows.	• 2 geometries tested. • Mach number distribution peak located mainly in the upstream part of the profile or in the downstream part.	2	Mach number Reynolds Strouhal Incidence
Study of the secondary flows	Study of the secondary flows development near the end walls for different values of the pitch over chord ratio. Study of the addition of a 3D endwall contouring.	• Two geometries tested. • For each blade, different pitch over chord ratios are tested. Pitch over chord ratios are between 0.60 and 1.10 • One configuration with non-axisymmetric endwall contouring.	2	Mach number Reynolds Strouhal Incidence
Impact of the trailing edge thickness	Study of the trailing edge geometry (thickness, dihedron) on the profile losses and shock waves location.	• One additional profile optimized for performance	1	Mach number Reynolds Strouhal Incidence
Impact of the surface condition (roughness)	Study of the impact of surface condition (mainly roughness) on total losses and on the state of the boundary layer.	• Undefined configuration with 1 different surface condition.	1	Mach number Reynolds Strouhal Incidence

<u>Blade design</u>

The airfoil geometries to be tested are not yet entierly set. The tests will focus on transonic highly loaded airfoils, typically rotors and stators of the last stages of high speed LPTs. These airfoils are characterized by high Mach number values.

The following table contains a first estimation of the airfoils geometric properties at scale 1:1:

Geometric properties (scale 1:1)		
	Chord (mm)	***Pitch over chord ratio***
Minimum value	>30	0.60
Maximum value	<50	1.10

At scale 1:1, the test section must allow chords between 30mm and 50mm.

The scale may be adapted in accordance with test bench capacities and airfoil surface instrumentation. However, the Strouhal numbers must be kept following a scaling of the airfoil.

The design of the airfoil geometries will be done and supplied by Snecma.

The blades will be manufactured by the Partner. The blades will be controlled and approved by Snecma before each test campaign.

4. <u>Special skills, Capabilities, Certification expected from the Applicant(s)</u>

- Experience in High speed cascade tests for LPT airfoils is mandatory. Availability of associated test benches.
- Capacity of airfoil manufacturing.
- Existing cascade facilities that would enable to start test campaign
- Availability of necessary test benches to support the campaign is mandatory. The following capacities and equipments is mandatory:
    - High speed test capacity
        - The isentropic exit Mach number range mandatory is [0.45; 1.20], which corresponds to an expansion rate range of [1.0; 1.8] (total to static pressure ratio).
    - Low Reynolds tests capacity
        - The Reynolds number range (based on true chord) to consider is [75000; 500000].
        - For each configuration, Reynolds influence on losses will be tested.
    - Inlet turbulence intensity levels required are between 5% and 12%. Inlet turbulence

level must be adaptable to the configuration tested.

- Wake generator
  - The High Speed Turbine feature Strouhal number range is [0.15; 1.4]. Rotating bar diameter is not frozen yet but should be consistent with the value given by Snecma at T0.
- Optical flow visualization system to catch in real time shock waves topology around the blade and boundary layer separation if any.
- Expected results and measurements :
  - Inlet total and static pressure
  - Inlet temperature
  - Inlet flow angle
  - Inlet turbulence level using hot wire (could be done once for each grid before test).
  - Pitchwise measurements (static pressure, flow angle...) at mid-span over one or several pitches at outlet
  - Downstream full 2D mapping (radial and tangential) for some configurations close to one endwall (test #4 only).
  - Total pressure losses for every configurations + effect of variation of Strouhal, Reynolds, Mach & Incidence.
  - Isentropic Mach number distribution along the blade at mid-span (pressure and suction side of the same flow passage). Number of pressure probes on the suction side of the profile downstream of the throat should be at least 15. Overall number on pressure side & suction side to be agreed at T0.
- Hot film on the base case to characterize the boundary layer state
- Hot wire probe
- Fast response air probes

- Tests benches and equipment compliant to international standard
- English language is mandatory

5. Abbreviations

LPT	Low Pressure Turbine

II. 2 VBV actuators (LHS & RHS) for Ground Test Demo / 2 VSV booster actuators (LHS & RHS) for Ground Test Demo

Type of action (RIA or IA)	IA		
Programme Area	ENG - WP 2 – Ultra High Propulsive Efficiency		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	1800 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	36 months	**Indicative Start Date**[46]	Q2 2017

Identification	Title
JTI-CS2-2016-CFP04-ENG-01-11	**2 VBV actuators (LHS & RHS) for Ground Test Demo** **2 VSV booster actuators (LHS & RHS) for Ground Test Demo**
Short description	
Supply two variable bleed valve actuators and two variable stator vanes actuators for UHPE Ground Test Demo including current definition products and specific products that will be necessary due to the characteristics of UHPE Ground Test Demo. Innovative design is required in order to meet demo specification and to provide significant weight savings and room benefit versus existing standards.	

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

1. Background

The UHPE Demonstration Project aims at designing, manufacturing & testing a Ultra High Propulsion Efficiency Engine Demonstrator. It involves most of the best European Engine & Engine Modules & Sub-systems Manufacturers.

Booster Variable Stator Vanes are controlled to protect booster operability. They are scheduled as a function of corrected core speed. Two booster VSV Actuators are used to control the position of booster inlet guide vanes.

Variable Bleed Valves are also controlled to protect booster operability. They are scheduled as a function of corrected fan speed and corrected core speed. Two VBV actuators are used to control the position of guiding rod system linked to VBV doors in primary airflow.

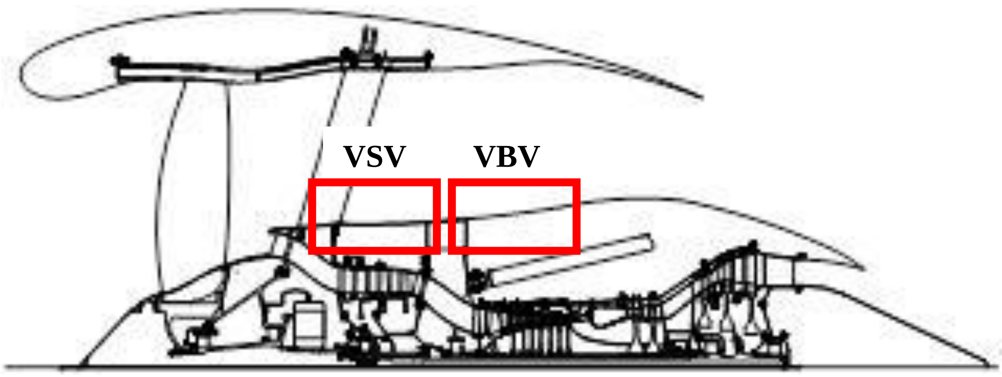
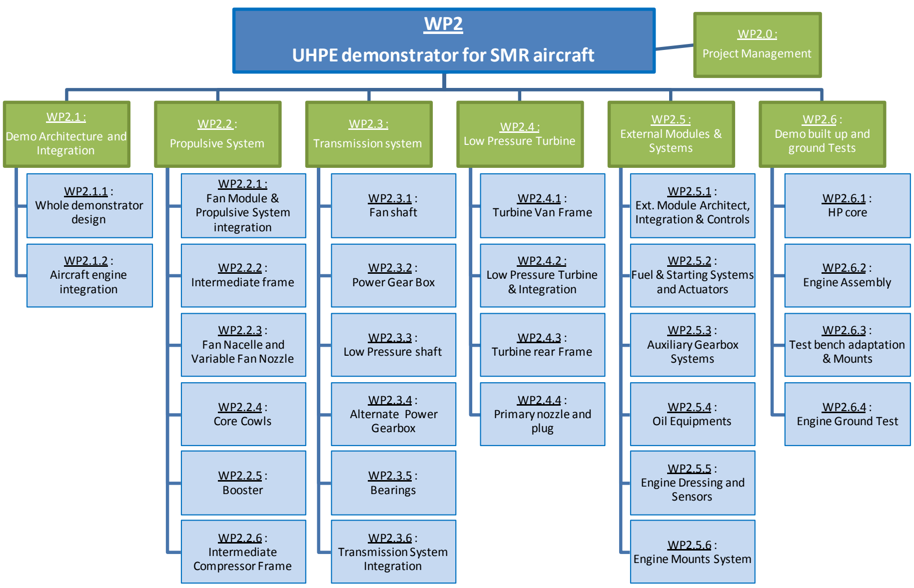


Figure 1 : UHPE baseline with VSV & VBV actuators locations

The breakdown in this WP2 is the following :



2. Scope of work

The partner will provide a complete set of two booster VSV actuators and two VBV actuators for the demonstrator plus a set of spare for both systems.

According to the UHPE requirements, innovative design on actuactors could be necessary in order to provide significant weight savings and room benefit versus existing standards. Attention need to be focused on accuator's sized and on thermal environment.

From now is assumed that actuators will be Hydraulic ones. Sizes, weight and main characteristics will be define during the Engine Concept Review (Q2/2016).

Actuators are specified in WP 2.5.1 “Ext. Module Archi. Integr & Controls”, specific risk reduction plan is conducted in WP2.5.2 “Fuel & Starting Systems and Actuators”. Actuators are designed and manufactured and matured (if needed) in WP2.5.2, assembled within the VSV or VBV system module in WP2.2.1 “Fan Module & Propulsive Syst. Integration”, assembled with the engine in WP2.6.2 ”Engine Assembly” and tested in WP2.6.4 “Engine Ground Test”.

Actuators will include servo valve used for actuation with an LVDT (Linear Variable Differential Transformer) to provide position feedback.

DIAGRAMME GANT - UHPE - cfp Actuators		2017				2018				2019				2020			
REF	Label	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	CFP ACTUATORS																
T0	Management and reporting																
T1	Risk reduction plan																
M1	Risk reduction plan review																
M2	Risk reduction plan : Completion review																
T2	– Requirements																
M3	CS2/WP2 - D1 : Actuators Specifications																
T3	Actuators system architecture																
T4	Actuators Preliminary design																
M4	CS2/WP2 - M2 : PDR																
T5	Actuator Detailed design																
M5	CS2/WP2 - M3 : CDR																
T6	Justification of reliability for ground test demonstrators.																
T7	Manufacturing																
T8/M6	Hardware delivery for demo engine																
M7	CS2/WP2 - D2 : engine & bench ready for ground tests																
T9	Performance evaluation on demonstrator ground test																
TRL						3					5						

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 0	*Actuators – 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 + 35 months
Task 1	*Actuators - Risk reduction plan* To provide and achieve a plan including test and capability demonstration for each technical element	T0 + 12 months
Task 2	*Actuators – Requirements* To contribute to the UHPE demonstrator actuators specification written under SNECMA leadership.	T0 + 6 months
Task 3	*Actuators architecture* To propose and finalise a system architecture including servo valve used for actuation with an LVDT algorithms to monitor actuator position.	T0 + 9 months
Task 4	*Actuators - Preliminary design* To perform preliminary design of UHPE actuators complying with the specifications provided by WP2.5.1	T0 + 12 months
Task 5	*Actuators - Detailed design* To perform detailed design of UHPE smart and conventional Bearings complying with the specifications provided by WP2.5.1	T0 + 15 months
Task 6	*Actuators – Justification of reliability of actuators technology for ground test demonstrators.* To provide justification documents for the CDR, compliance matrix to specification and results of risk reduction plan	T0 + 18 months
Task 7	*Actuators – Manufacturing* To manufacture • Two booster VSV actuators, • Two VBV actuators complying with the specifications provided by WP2.5.1	T0 + 20 months
Task 8	*Actuators- Hardware deliver for demo engine* To deliver • Two booster VSV actuators, • Two VBV actuators complying with the specifications provided by WP2.5.1.	T0 + 20 months

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 9	*Actuators- Performance evaluation on demo engine*	T0 + 35 months

3. Major deliverables and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type (*)***	***Due Date***
D1	*Actuators management plan*	R	T0 + 2 months
D2	*Actuators - Risk reduction plan – Intermediate report*	R and RM	T0 + 3 months
D3	*Actuators – Requirements*	R and RM	T0 + 6 months
D4	*Actuators system architecture*	R and RM	T0 + 9 months
D5	*Actuators - Risk reduction plan completion –Test Report*	R	T0 + 12 months
D6	*Actuators - PDR*	R and RM	T0 + 12 months
D7	*Actuators - Detailed design* Delivery of CAD files	D	T0 + 15 months
D8	*Actuators – CDR*	R and RM	T0 + 15 months
D9	*Actuators – Hardware delivery*	D	T0 + 20 months
D10	*Performance evaluation on demonstrator ground test - final report and synthesis*	R and RM and D	T0 + 35 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 review*	RM	T0 + 2 months
MS 2	*Risk reduction plan* *Completion review*	RM	T0 + 12 months
MS 3	*CS2/WP2 - D1 : Specifications*	RM	T0 + 6 months
MS 4	*CS2/WP2 - M2 : PDR*	RM	T0 + 12 months
MS 5	*CS2/WP2 – M3 : CDR*	RM	T0 + 15 months
MS 7	*CS2/WP2 - D2 : engine & bench ready for ground tests*	RM	T0 + 27 months

4. Special skills, Capabilities, Certification expected from the Applicant

- Experience in design, manufacturing, testing and certification of aircraft engine actuators is mandatory
- Experience systems tests or other relevant tests contributing to risks abatement is mandatory
- Availability of test benches to support test campaign is mandatory
- English language is mandatory

5. Abbreviations

VBV	Variable Bleed Valve
VSV	Variable Stator Vane
PDR	Preliminary Design Review
CDR	Concept Design Review
LVDT	Linear Variable Differential Transformer

III. Development of the investment casting process and weldability for high temperature capable superalloys

Type of action (RIA or IA)	IA		
Programme Area	ENG - WP 2 – Ultra High Propulsive Efficiency		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	700 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	36 months	**Indicative Start Date**[47]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-ENG-01-12	**Development of the investment casting process and weldability for high temperature capable superalloys**
Short description (3 lines)	
Develop the investment casting process and weldability for high temperature superalloys for example by tailoring the casting solidification structure, adapting the thermal processing or by minor alloy chemistry adjustments, in order to improve weldability of a number of commercially available alloys.	

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

1. Background

The Clean Sky 2 programme aims at developing and demonstrating competitive and environmentally friendly technology for commercial air transport. One technology strand consists of demonstration of a new engine architecture called UHPE (Ultra High Propulsive Efficiency Engine) for a short/medium range aircraft. The new architecture will be demonstrated through an engine ground test and a wide range of new components need to be developed and manufactured. Activities are underway to develop technologies for the TRF (Turbine Rear Frame illustrated to the right) which will be made from high temperature Ni-base superalloys. This component type is currently made from single piece castings or fabricated assemblies including different material forms like castings, forgings and sheet.

High temperature capable, strong superalloys exists today (such as RS5, CM939 Weldable® , Weldable Waspaloy, RENE® 220, ATI 718Plus® but not limited to these alloys) but they are difficult to use for large, complex, integrally cast or fabricated - structures. The reasons are combinations of problems related to the cast/heat treat process, the foundry weld repair process and in the weld assembly process. This CfP topic will advance the possibilities to use these alloys as castings in a welded assembly. The results from the project will enable engine structures to reduce weight and cost by allowing a wider range of alloys to be used and by improving the quality of structural welds in castings to reduce the amount of rework needed in the assembly welding process. The approach will be to improve the physical understanding of the following aspects and:

- Tailor casting solidification structure - grain size and microstructure - to improve weld quality. As an example; control of the solidification structure by using a directional solidification furnace for producing equiaxed casting is considered to be interesting to explore.
- Adapt thermal processing (Hot Isostatic Pressing and heat treatment).
- Possibly do minor alloy chemistry adjustments of a number of commercially alloys (two plus IN718C).

The final effect on weldability will be quantitatively assessed using different weldability test methods.

Cast IN718 is to be used as reference for all trials.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
1	**Management** Organisation: – The partner shall nominate a team dedicated to the project and should inform CfP Topic manager about the name/names of this key staff. At minimum the responsibility of the following functions shall be clearly addressed: Programme (single point contact with Topic Manager), Engineering & Quality. 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 teleconferences). – The partner shall support reporting and agreed review meetings with reasonable visibility on its activities and an adequate level of information.	T0 + 1M
2	**Weldability and ways of improving cast microstructures** Perform down selection of alloys (two alloys plus cast IN718 as reference) in cooperation with Topic Manager. Literature surveys on: (i) Weldability of cast material (examples but not limited to influence of; chemistry variations, grain size and microstructure, heat treatment). (ii) Techniques, applicable to a foundry in achieving robust weldable castings such as grain refinement techniques, solidification control etc. (iii) Innovative welding techniques more suited for cast material. Propose trials to be cast and tested with the most promising techniques/parameters found in above surveys. Generate basic material data (using either publicly available material data, simulated or experimentally derived material data) for selected alloys to be used for (i) casting and (ii) welding simulations.	T0 + 12M

Tasks		
Ref. No.	***Title - Description***	***Due Date***
3	**Casting** Casting simulation (fill and solidification) to be performed for the chosen alloys using data generated in Task 2. Perform castability trials using vacuum investment casting of the selected alloys to establish fill and feed characteristics and hot tear sensibility of the chosen alloys. The CfP partner and Topic Manager will commonly agree on geometries and test procedures for the initial casting trials. Based on task 2 results, cast test material such as plates, rods etc for weld trials in selected high temperature alloys and base line/reference alloy IN718. Limited mechanical testing; tensile (at room temperature and elevated temperature) and stress-rupture of representative material to be included. Microstructural characterization of cast material to be performed on all of the selected alloys.	T0 + 22M
4	**Weldability** Analyze and establish robustness targets for a typical fabrication weld using wrought IN718 as reference. Using the cast samples from Task 3, perform weldability evaluations doing; (i) Gleeble, Varestraint testing etc. (ii) Repair welding, simulating typical foundry rework. (iii) Structural welds, simulating component like geometries (welding different thicknesses and using both conventional welding techniques and innovative techniques from Task 2). Microstructural characterization of pre- and post-welded material should be performed and linked to the underlying mechanisms associated with weldability. Compare results with target values and propose second iteration for further improvements.	T0 + 34M
5	**Casting of component-like geometries** As the final activity of this project a component like geometry will be cast. The geometry to be used shall be selected in cooperation with the Topic Manager. The demonstrator part shall be cast using (i) the selected high temperature alloys and (ii) IN718 as reference in approximately 4-5 units/alloy. This is to verify that the process parameters and weldability improvement techniques developed in task 2, 3 and 4 are meeting the robustness targets established in task 4. The castings will undergo dimensional control, x-ray inspection and will be cut up for microstructural investigation.	T0 + 34M

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1.1	Detailed project plan	R	T0 + 1M
D2.1	Documentation: Literature Survey on weldability	R	T0 + 2M
D2.2	Documentation: Literature Survey on foundry techniques available for improved structure.	R	T0+8M
D2.3	Documenation: Literature survey of innovative welding techniques	R	T0+8M
D2.4	Trial Plan	R	T0 + 12M
D2.5	Documentation of generated material data for simulation	R	T0 + 12M
D3.1	Documentation of results from castability test.	R	T0 + 22M
D4.1	Documentation of weldability trials	R	T0 + 34M
D5.1	Documentation of component like casting trial.	R	T0 + 34M
D1.2	Final report summarizing all results and findings within this WP.	R	T0 + 36M

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

Milestone			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M2.1	Alloy selection	R	T0+2M

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

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

The CfP partner/consortium needs to have;

- (i) extensive documented knowledge about superalloys such as thermal processing and microstructure etc.
- (ii) experience in performing applied collaborative industrial research in international environment.

The CfP partner/consortium needs to;

- (i) master vacuum investment casting of complex geometry parts in Ni-base superalloys up to 360x270x150mm, weighing approximately 7 kg.
- (ii) have knowledge of grain refinement techniques for equiaxed structural castings, such as - but not limited to; use of inoculants, use of chill coat, use of novel/unconventional casting techniques.
- (iii) have furnaces for heat treatment in vacuum (or other suitable protective atmosphere).
- (iv) have testing and analysis equipment for evaluating the casting trials, or an available supply network. This includes e.g. dimensional control, fluorescent penetrant inspection, X-ray, metallography and mechanical testing according to aerospace standards.

It is beneficial if the CfP partner/consortium has;

- (i) extensive experience in numerical simulation of the casting process as well as experience from casting using Rapid Prototype patterns such as SLA/SLS or similar.
- (ii) access to vacuum investment casting furnaces which can be used to control the solidification thermally. A process which uses the withdrawal mode similar to that used for directional solidified airfoils to produce equiaxed structural castings.
- (iii) In-house manufacturing of start material (cast stick) for casting or alternatively a well established relationship with supplier(s) of cast stick which are able to supply cast stick in smaller quantities (experimental heats), 20-100 kg. (iv) access to material simulation software such as JMatPro® or Thermo-Calc and equipment such as DTA (differential thermal analysis) or DSC (differential scanning calorimetry).

The CfP partner/consortium needs to;

- (i) have extensive knowledge on superalloy weldability.
- (ii) have equipment or an available supply network for weldability trials including TIG, laser, and weldability testing equipment like varestraint, gleeble etc.
- (iii) have testing and analysis equipment for evaluating the material after the test campaigns, or an available supply network that can perform these evaluations. This includes e.g. equipments such as TEM-EDX , SEM-EDX (transmission- and scanning- electron microscopy including energy-dispersive X-ray spectroscopy and LOM (optical microscopy).
- (iv) have equipment or an available supply network for creep and tensile testing, at temperatures between room temperature and up to 850C. Mechanical testing laboratories should be ISO17025 ILAC approved for test specimen machining and the test methods. Test results shall be reported as ISO17025 accredited.

IV. High load gear and bearings materials

Type of action (RIA or IA)	IA		
Programme Area	ENG - WP 2.3.4 – UHPE Alternate Gearbox (IDS Module)		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	450 k€	Type of agreement	Implementation Agreement
Duration of the action (in Months)	24 months	Indicative Start Date[48]	Q2 2017

Identification	Title
JTI-CS2-2016-CFP04-ENG-01-13	High load gear and bearings materials
Short description	
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. Classical aerospace materials, although performant, do not exhibit all the necessary technical characteristics order to fulfil both bearing and gears strength needs. Moreover higher oil temperature will characterise new gearboxes usage. The above requirements will focus the activities not only on ambient testing but also on high oil temperature condition. After joint selection activities of promising materials and surface treatments, the applicant will manage the procurement of bearing and gear test articles, perform testing activities on bearings also in contaminated conditions, and on gears through high load and high temperature testing that will reproduce conditions similar to those of new engines.	

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

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 a 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 ENGINE ITD-WP2 aims at developing and testing the UHPE demonstrator substantiating the UHBR concept as a 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 summarizes 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 (Critical To Quality) 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 materials for gears and 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 manager will periodically meet the applicant in person or via teleconference in order to accurately track the evolution of the tasks.

The applicant shall perform the following tasks:

T1 Specification and materials/heat treatment selection

In cooperation with the topic manager, a number of potential applicable steel materials and related surface treatments will be selected, according to commercial (i.e. cost, availability, supplier base) and technical criteria (i.e. mechanical characteristics), fulfilling the power density requirements of geared engine systems. Among the candidates the focus will be on innovative high strength materials as M50NiL, FerriumC61, Pyrowear675.

Proposals for the materials will be responsibility of topic manager. Specific attention will be focused on high strength and hot temperature (T>200°C) expected behaviour. Among the materials a limited list of promising steels and treatments will be jointly and finally the topic manager that will approve the selection.

T2 Test articles and STBF hot oil test rig design

Since the single tooth bending fatigue test is the most time- and cost- effective for assessing the gear bending fatigue limit, the applicant shall:

- design appropriate gear test articles
- design a device able to effectively load a single tooth of the test article in a deterministic condition (i.e. tangential to normal tooth force ratio limited by fixture design and measured) in ambient temperature and when immersed in hot oil (temperature of oil up to 200°C)
- define a test plan, minimising the number of test articles, in order to be able to provide 99% reliable fatigue limit with 95% confidence level in hot and cold conditions.

The target of the above tasks will be the capability to perform testing to estimate the allowable fatigue limit and related standard deviation, i.e. testing above and below the fatigue limit. The applicant shall consider the fact the obviously the actual fatigue limit will not be known at such stage and some reasonable margin will be necessary.

The applicant shall design the test articles, the rig device and plan the test type in order to deliver to the topic manager actual tensile fatigue strength values, not only a comparison of behaviour among different test articles.

All the above activities will be reviewed and approved by the topic manager.

T3 High torque power circulating rig design

Since some specific surface wear conditions, as pitting and scuffing, cannot be reliably reproduced in specimen testing, full component test has to be performed on a circulating power rig.

The applicant shall:

- design appropriate gear test articles, enhancing if possible, commonalities with STBF design
- the topic manager will validate and approve the design
- design a power circulating device able to deliver different loading conditions on the gear test articles: torque up to 750Nm and speed up to 12000 rpm or specifically torque up to 500Nm and speed up to 18000 rpm. Temperature of gear oil shall be up to 200°C.
- define a test plan, including the number of test articles, in order to be able to provide:
    - 99% reliable fatigue limit with 95% confidence level in hot and cold conditions.
    - 99% reliable scuffing T limit with 95% confidence level in hot and cold conditions

The applicant shall design the test articles, the rig system and plan the test type in order to deliver to the topic manager actual contact fatigue strength values, and scuffing temperatures, not only a comparison of behaviour among different test articles.

The rig specifications design and features will be approved by the topic manager.

The test articles and the test plan will be approved by the topic manager.

T4 STBF hot oil test rig procurement and commissioning

The applicant, upon rig design approval by the topic manager, shall procure the STBF device for testing the gears also in hot oil.

The applicant shall perform the commissioning operations in strict accordance with the topic manager that will be given a formal clearance to effective testing.

T5 Bearing specimen design and manufacturing for different materials/processes

The bearing test articles will be designed by the applicant according to his experience so that both clean oil fatigue testing and contamination-like conditions can be tested in relevant pressure levels similar to application requirement. The design of bearings, the test plan (and size of batch) will be defined in accordance with the topic manager, in order to be able to:

- statistically compare a baseline material to another material (relative life factor)
- estimate also the spalling-resistance limit strength of various materials

Testing has to be performed by the applicant in existing or slightly modified facilities.

The applicant will manufacture the bearing batches for the testing. The potential bearing batches quality issues will be notified to the topic manager that shall decide whether test articles will be acceptable or not acceptable.

Calculation of Test articles will be made by the applicant and approved by the topic manager.

T6 High torque power circulating rig procurement and commissioning

The applicant, upon approval by the topic manager, shall procure the power circulating device for testing the gears also in hot oil.

The applicant shall perform the commissioning operations in strict accordance with the topic manager that will give a formal clearance to test.

T7 Gear specimen manufacturing for different materials/processes materials

The applicant will manufacture the gears according to technical specifications agreed with the topic manager. The potential gear batches quality issues will be notified to the topic manager that shall decide whether test articles will be acceptable or not acceptable.

T8 Hot / Cold Gear STBF testing

The applicant will test the gears made in different material batches, through the STBF device; each material/surface combination in cold and hot conditions (temperature to be agreed with the topic manager) for accurate comparison and determination of both – cold and hot - fatigue limits, the hot and cold oil standard deviations, the hot and cold LCF slope for each batch.

The test results will be shared in a timely manner to the topic manager.

T9 Gear PC high torque testing (pitting, scuffing)

The applicant will test the gears made in different material batches in the power circulating rig at high torque conditions in order to determine the pitting fatigue limit and its standard deviation; then the applicant will perform the scuffing temperature evaluation test and its standard deviation estimate. Both tests will be run at high oil temperature to be agreed with the topic manager (potentially T up to 200°C).

The test results will be shared in a timely manner to the topic manager.

T10 Bearing testing in contaminated / hot oil conditions

The applicant will perform the bearing fatigue test in order to determine the reliability of the race/roller material combinations using test procedure able to:

- statistically compare a baseline material to another material (relative life factor)
- estimate also the spalling-resistance limit strength of various materials.

Testing temperature will be agreed with the topic manager (potentially oil temperature up to 200°C).

T11 Results analysis

After the termination of all the tests, the applicant, in accordance with the topic manager, will critically analyse the results, taking into account potential outliers and/or non-typical results providing for all materials combinations:

- a full estimate of bending/pitting fatigue limits and their confidence on bearings and gears
- an estimate of scuffing temperature and its standard deviation

Tasks		
Ref. No.	***Title - Description***	***Duration***
T1	Specification and materials/heat treatment selection	Mo1
T2	Test articles and STBF hot oil test rig design	Mo1-Mo3
T3	High torque power circulating rig design	Mo1-Mo3
T4	STBF hot oil test rig procurement and commissioning	Mo4-Mo6
T5	Bearing specimen design and manufacturing for different materials/processes materials	Mo2-Mo8
T6	High torque power circulating rig procurement and commissioning	Mo4-Mo9
T7	Gear specimen manufacturing for different materials/processes materials	Mo2-Mo10
T8	Hot / Cold Gear STBF testing	Mo11-Mo18
T9	Gear PC high torque testing (pitting, scuffing)	Mo11-Mo23
T10	Bearing testing in contaminated / hot oil conditions	Mo10-Mo23
T11	Results analysis	Mo20-Mo24

Mo: month from T0

3. Major deliverables/ Milestones and schedule (estimate)

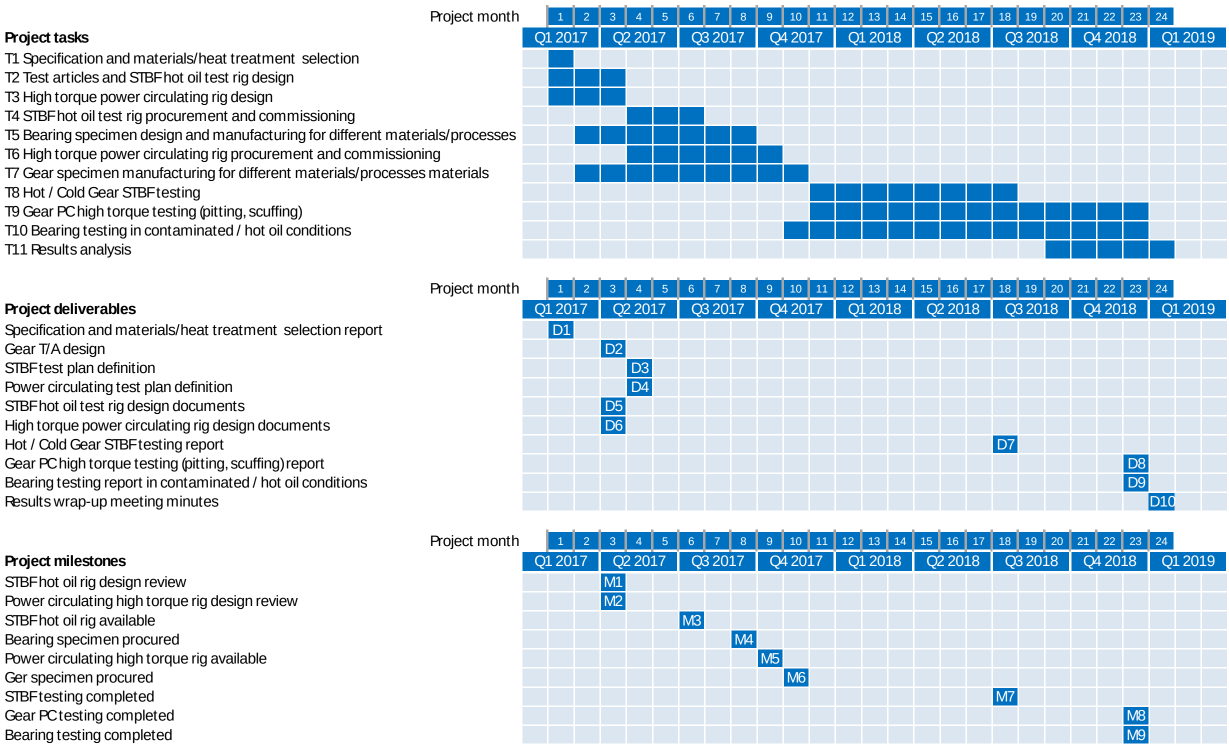
Deliverables			
Ref. No.	***Title - Description***	***Type (*)***	***Due Date***
D1	Specification and materials/heat treatment selection report	R	T0+1 months
D2	Gear T/A design	R	T0+3 months
D3	STBF test plan definition	R	T0+4 months
D4	Power circulating test plan definition	R	T0+4 months
D5	STBF hot oil test rig design documents	R	T0+3 months
D6	High torque power circulating rig design documents	R	T0+3 months
D7	Hot / Cold Gear STBF testing report	R	T0+18 months
D8	Gear PC high torque testing (pitting, scuffing) report	R	T0+23 months
D9	Bearing testing report in contaminated / hot oil conditions	R	T0+23 months
D10	Results wrap-up meeting minutes	R	T0+24 months

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	STBF hot oil rig design review	R	T_0+3 months
M2	Power circulating high torque rig design review	R	T_0+3 months
M3	STBF hot oil rig available	HW	T_0+6 months
M4	Bearing specimen procured	HW	T_0+8 months
M5	Power circulating high torque rig available	HW	T_0+9 months
M6	Gear specimen available for testing	HW	T_0+10 months
M7	STBF testing completed	D	T_0+18 months
M8	Gear PC testing completed	D	T_0+23 months
M9	Bearing testing completed	D	T_0+23 months

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

Schedule for Topic Project (Level 2 Gantt) – *see next page*



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:

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.

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.

Gears:

Extensive experience in testing of gears for high performance aerospace application.

The Applicant needs to demonstrate to be in the position to have access to the test facilities required to meet the Topic goals (Single Tooth Bending Fatigue Rig)

Experience in aerospace R&T and R&D programs.

Special Skills:

- Experience in gear design and LTCA (for T/As design)
- Experience in Supply Chain management (for T/As procurement)
- Experience in experimental testing and Statistical Methodologies (for Test Plan definition and execution).

V. Experimental & Numerical analysis dedicated to FOD Management for Turboprop Air intake

Type of action (RIA or IA)	RIA		
Programme Area	ENG - WP3		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	950 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	48 months	**Indicative Start Date**[49]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-ENG-01-14	**Experimental & Numerical analysis dedicated to FOD Management for Turboprop Air intake**
Short description	
The purpose of the study is to verify the efficiency of the Inlet Particle Separator (IPS) of the Turboprop air intake. Numerical & experimental investigations will be conducted to assess the air intake and IPS geometry for FOD management (water, sand).	

[49] 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.

A full Integrated Power Plant System (IPPS) will be ground tested. To assess the aerodyanmic design of the air intake and the efficiency of the Inlet Particle Separator (IPS) of the air intake, a comprehensive study is necessary.

The IPPS is illustrated in figure 1, which shows the air intake and the IPS exhaust at the bottom of the engine, behind the propeller. The figure 2 shows the work breakdown structure of the whole demonstration platform.

Figure 18: Illustration of Integrated Power Plant System (IPPS)

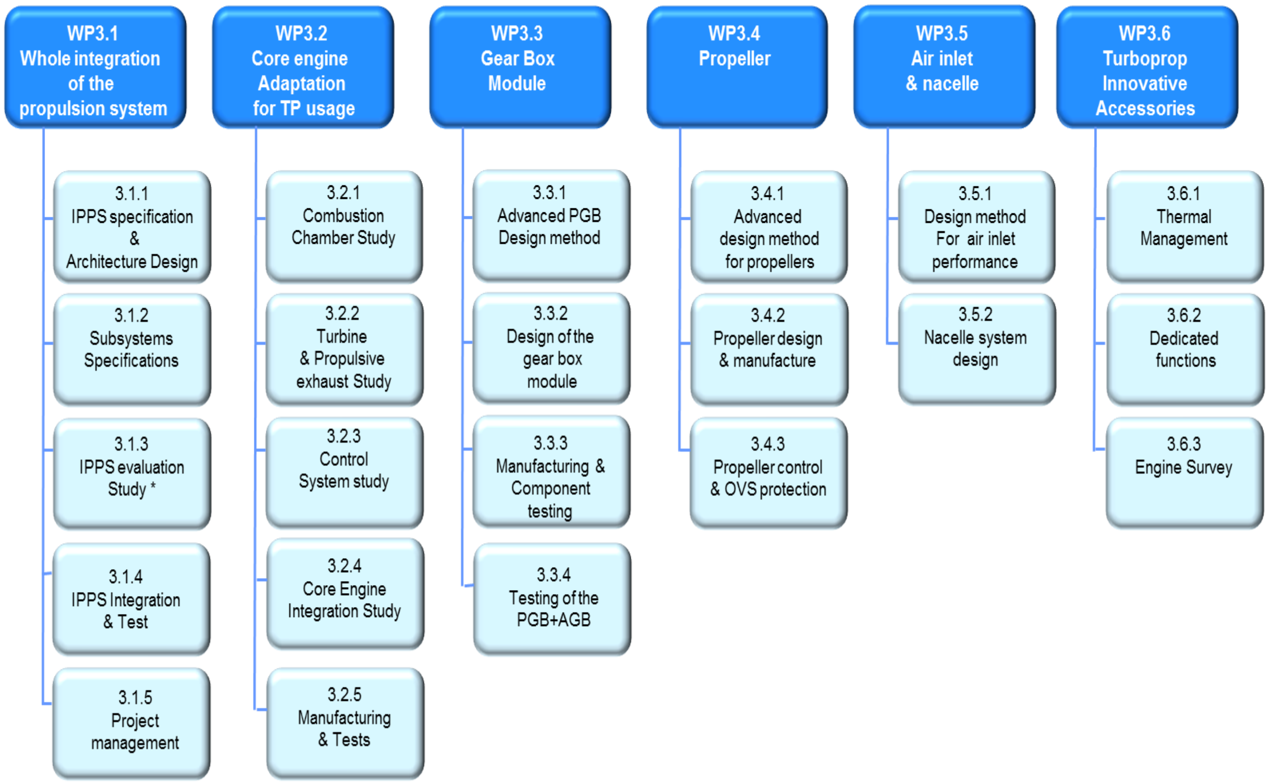


Figure 19: WP3 Workbreakdown structure

2. Scope of work

A full Integrated Power Plant System (IPPS) will be ground tested. However, to assess the aerodynamic design of the air intake and the efficiency of the Inlet Particle Separator (IPS) of the air intake, a dedicated and comprehensive study is necessary.

Therefore this CfP aims at analyzing and understanding air flow structures and particles behavior developing within an air intake with IPS to assess the design methods.
The IPS main function is to separate the particules (solid : sand, gravels, etc.. and liquid : water droplets) from the main engine airflow before it enters the compressor. In the mean time, a certain amount of airflow to the engine must be guaranteed to maintain a minimum amount of power. Turbomeca's goal is to be able to assess, as early as possible, the IPS efficiency, using RANS Simulation, in order to secure and shorten the design process.

Numerical studies will be performed to analyze the flow structures and discrete particles trajectory in order to develop numerical models that could, enventually, be integrated into a RANS model. Models will be assessed and validated using experimental results that will be obtained during the project. An experimental set-up will thus be proposed with representative geometries of the air intake & IPS.

Following the air flow analysis, the efficiency of the IPS (capability to separate the discrete particules and the airflow going into the engine) will be evalued in a second step of the project using both experimental and numerical tools. Experimental investigations of a scaled air intake will be proposed to assess the efficiency of the IPS for water and solid particles ingestions. Numerical simulations will be performed to understand the influence of geometrical parameters. In particular, the experimental set-up will simulate the effect of the propeller on inlet air flows. The experimental investigation will not involve the propeller but the applicant will propose a solution to simulate the swirl that a propeller would induce. A test set-up will thus be proposed to generate the air flow within the air intake model without external air flow in order to validate effect of the isolated air intake regarding FOD management.

The main technical requirements are listed below:

- Water (rain)
- Sand particles (particle sizes averaging from 20 µm to 200 µm with concentrations of the order from 53 mg/m3 to 100 mg/m3),
- Several positions of the IPS will be tested
- The scale of the air intake mock-up will be as close as possible to 1:1
- At scale 1:1, the air flow ranges from 1.5 kg/s to 6.5 kg/s
- The scale 1:1 air intake enters a volume of 1300 x 600 x 800 mm

At this stage of the programme, about 30 different test configurations are estimated, based on the following test matrix.

Parameter	Water concentration	Sand concentration	Air flow	IPS positions
No of points	5	5	5	2

The above preliminary test matrix is a minimum given for indication only and will be subject to discussions during the programme.

In additionnal activities to the above requirements, tests with snow or ice particles are of strong interest and a study could be proposed.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 0	*Air intake & IPS design assessment – Management and reporting* **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 + 48 months
Task 1	*Air intake & IPS design assessment – Concept studies* Understanding of general multi-phase flow phenomena in air intake with IPS. Development of CFD models, focused on discrete phase modelling, to be integrated in RANS CFD solvers (for solid particles). Experimental investigation to be conducted to assess numerical simulations.	T0 + 36 months
Task 2	*Air intake & IPS design assessment – IPS efficiency assessment* Experimental study of IPS efficiency with water and sand ingestion (possibly snow). Numerical simulations to assess methodologies and predictions accuracy for solid particles.	T0 + 36 months

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type (*)***	***Due Date***
D1	Technical Report to substantiate the general approach that is proposed	R	T0 + 1 month
D2	Specification of numerical and experimental validation campaign (description of simplified test cases, measurement campaign and numerical methods and outputs)	R	T0 + 6 months

Deliverables			
Ref. No.	***Title - Description***	***Type (*)***	***Due Date***
D3	CFD report on air flow analysis and LES on validation benchmarks (mesh convergence studies and blind computations)	R	T0 + 18 months
D4	Experimental and numerical test campaign results including validation and reference data for RANS (extract data for validation of RANS models)	R	T0 + 24 months
D5	Technical reports with models and methodologies and validation on benchmarks (description of RANS methodology)	R	T0 + 36 months
D6	CFD report on RANS simulations with new laws implemented	R	T0 + 36 months
D7	Experimental report of air intake mock-up with water & sand ingestion The report will present the data and propose an analysis of the air flow/particles behavior	R	T0 + 42 months
D8	CFD intermediate report on IPS efficiency assessment (computations and sensitivity analysis on full geometry)	R	T0 + 44 months
D9	Final report Synthesis report compiling main technical results and conclusions	R	T0 + 46 months

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
MS 1	Strategy selected for air flow analysis – Specification for the numerical and experimental validation campaigns, preliminary results	RM	T0 + 12 months
MS 2	First review on FOD management – Results of flow structure investigations & presentation of experimental set-up for FOD studies	RM	T0 + 24 months
MS 3	Second review on FOD management – New laws for RANS computations validated & preliminary experimental results on FOD ingestion	RM	T0 + 36 months
MS 4	Final Review meeting	RM	T0 + 48 months

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

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

Technologies such as Aerodynamic, Aeromechanical, Mechanical, Material, Manufacturing and Methods will be required for supporting the experimental investigations.

Strong expertise in CFD simulations (including LES, URANS & RANS) with multi-phase flows and analysis on aerodynamics is required.

The partner will demonstrate to have recognized skills in turbomachinery in:

- Aerodynamic & Mechanics
- HPC CFD simulations
- Testing (experimental investigations)

VI. Substitution of Chromium(VI)-based substances for corrosion protection of Aluminum- and Magnesium alloys

Type of action (RIA or IA)	RIA		
Programme Area	ENG - WP 4 Geared Engine Configuration		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	1 000 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	18 months	**Indicative Start Date**[50]	Q2 2017

Identification	Title
JTI-CS2-2016-CFP04-ENG-02-05	**Substitution of Chromium(VI)-based substances for corrosion protection of Aluminum- and Magnesium alloys**
Short description (3 lines)	
Substances based on Chromium (VI) are used for passivation / chromating of aluminium and magnesium alloys as a corrosion protection of the surface. These substances (chromium trioxide and dichromates) are subject to the REACH regulation and use will be forbidden from September 2017 on. The goal is to develop suitable substitutes.	

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

1. Background

In aerospace engines lightweight materials as Aluminum and Magnesium are used. Parts made from these materials must be protected against atmospheric corrosion by a surface treatment. Chromium trioxide has been used for more than 50 years to provide surface protection to critical components within the aerospace sector, where the products to which they are applied must operate to the highest safety standards in highly demanding environments for extended time periods. Surface treatments based on chromium trioxide have unique technical functions that confer substantial advantage over potential alternatives. These include:

- Outstanding corrosion protection and prevention for nearly all metals under a wide range of conditions;
- Active corrosion inhibition (self-healing, e.g. repairing a local scratch to the surface);
- Excellent adhesion properties to support application of subsequent coatings or paints; and
- Excellent chemical and electrical resistivity.

Due to the cancerogenesis of chromium(VI), alternatives for all key applications in the aerospace sector as the chromium conversion coating (CCC) should be developed and act as substitutes.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
WP1	**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 report and organise review meetings and provide adequate level of information.	During the whole Project

Tasks		
Ref. No.	***Title - Description***	***Due Date***
	• The review meetings shall be held in MTU Aero Engines facility. **General Requirements:** • The partner shall work to an established standard process.	
WP2	**WP2 Development of Magnesium conversion coating:** The aim is to find or develop a chromium (VI) free conversion coating for magnesium and magnesium alloys which has similar or better performance, than chromium(VI) conversion coatings (CCC). The properties of a chromium(VI) free conversion coating, like corrosion resistance and paintability should have similar or better quality than those from CCC. The alternative conversion coating should also protect small uncoated scratches, like CCC. Test material should be an AZ31B or similar magnesium alloy.	T0+15M
WP3	**WP3 Development of Aluminium Passivation** The aim is to find or develop a chromium (VI) free conversion coating for aluminium and aluminium alloys which has similar or better performance, than chromium(VI) conversion coatings (CCC). The properties of a chromium(VI) free conversion coating, like corrosion resistance, electrical contact resistance and paintability should be similar or better than those from CCC. The alternative conversion coating should also protect small uncoated scratches, like CCC do it. Test material should be a corrosion sensitive aluminium alloy containing a minimum of 2 % Copper, i.e. AlMg2Cu or similar.	T0+12M
WP4	**WP4 Development of Chromic Acid Anodisation Alternative** The advantage of a chrome(VI) acid anodisation (CAA) is a thin (approx. 3 µm) and dense aluminium oxide layer which creates no corrosion if the anodising solution remains on the part, i.e. in joint fissures, gaps, cracks etc. after the anodization. The chrome(VI) free alternative must have the same properties. Especially the anodizing solution must not be corrosive to the aluminium alloys in service if the solution remains in joint fissures, gaps or cracks on the part after anodization. The high cycle fatigue and low cycle fatigue of anodized aluminium alloys must not be more worse than from CAA.	T0+15M

Tasks		
Ref. No.	***Title - Description***	***Due Date***
WP5	**WP5 Tests and Validation** The quality assurance provisions according to AMS2473 must be met. All tests has to be done on both - chromium(VI) free alternative coatings and the chromium(VI) containing coatings (CCC and CAA) for comparative purposes. For all tests a minimum of 10 equal coated samples or more are necessary to get a minimum of statistical accuracy. The corrosion resistance should be tested in a neutral salt spray test (NSS) according to ASTM B117 or ISO 2792. The electrical resistance tests should only apply on conversion coated samples, not on the anodized variants. Electrical resistance tests on coated and bolted samples. Electrical resistance tests on coated, heat treated (100°C/24h) and bolted samples. The paint adhesion is to be tested according to EN ISO 2409 by cross-cut. Vibration tests like HCF (high cycle fatigue) must only be done on anodized aluminium samples to get data about the decrease of strength due to HCF in comparison with CAA samples. HCF tests need not be done on conversion coatings.	T0+18M

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1.1	Literature and patent research about corrosion protection of magnesium- and aluminium alloys by passivation and anodisation.	R	T0+06M
D2.1	Apply available products on corrosion sensitive Mg- alloys (i.E. AZ31B) on samples.	HW	T0+15M
D3.1	Apply available products on corrosion sensitive Al-alloys (i.e. AlMg2Cu) on samples. .	HW	T0+12M
D4.1	Apply available anodizing procedures on anodizeable Al- alloys .	HW	T0+15M
D5.1	Corrosion resistance test results in neutral salt spray chamber according to ASTM B117 / ISO 2792.	R	T0+18M
D5.2	Electrical contact resistance values as a function of temperature, Room temp. and heat treated at 100°C for 24h.	R	T0+18M

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D5.3	Paintability and paint adhesion by a cross-cut test according to EN ISO 2409.	R	T0+18M
D5.4	Vibration test results (High cycle fatigue) and life expectancy of anodized aluminium alloys	R	T0+18M

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	Alternatives are identified	R	T0+06M
M2	Samples are coated	HW	T0+15M
M3	Corrosion resistance is demonstrated	HW + R	T0+18M
M4	Electrical contact resistance, paintability and paint adhesion is demonstrated	HW + R	T0+18M
M5	High Cycle Fatigue (HCF) endurance is demonstrated, values are presented	R	T0+18M

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

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

The applicant(s) should have a chemical department / laboratory with all equipment which is necessary for developing chromium(VI) free applications as well as applying CCC and CAA for comparative purposes.

The applicant(s) should be able:

- to test the coatings according to ASTM B117 in a neutral salt spray chamber.
- to measure the electrical contact resistance of the coating by bolted samples.
- to paint and test (adhesion test acc. to EN ISO 2409) conversion coated samples.
- to do a HCF-Test.

VII. Small-Scale Spin Test for Hoop-Burst Overspeed Assessment

Type of action (RIA or IA)	RIA		
Programme Area	ENG - WP5/WP6		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	663 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	36 months	**Indicative Start Date**[51]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-ENG-03-13	**Small-Scale Spin Test for Hoop-Burst Overspeed Assessment**
Short description (3 lines)	
The aim of the project is to develop novel methodologies for assessing overspeed capabilities of new disc alloys. This will involve new rig designs and test capability as well as development of advanced correlations to enable transferability to component designs. This would consist of 3 main work-streams: 1.Design of a small spin test for hoop burst overspeed testing, 2.Commissioning of test rig and proof of concept tests and 3.Analysis of rig tests and development of the overspeed correlation.	

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

1. Background

Overspeed is an event where an engine component's rotational speed far exceeds the intended normal operation. Overspeed could potentially occur under circumstances such as shaft break, control system failure, over fuelling, or an intentional need for high thrust (emergency manoeuvres). To ensure continued airworthiness, there is a requirement under European Aviation Safety Agency (EASA) regulations to demonstrate a component's rotor integrity under overspeed condition (CS-E840). Furthermore, failure of high energy rotors is a serious concern for the safety of aircraft gas turbine engines, as the consequences represent a significant threat to the airframe and passengers.

In order to demonstrate safety and compliance with EASA rotor integrity requirements, it must be established by test, analysis, or a combination that a rotor will not burst when subjected to prescribed overspeed conditions. Traditionally this has been demonstrated by analysis using Chamber's criterion or read across from an appropriate full-scale rig test. However, this approach is associated with high cost and long lead times. This is why the concept of small scale component testing for overspeed recently became a subject of interest to Rolls-Royce. The ability to determine strength limits of critical parts whilst avoiding expensive full-scale component testing can provide significant economic advantages to the company. Furthermore, new failure criteria and correlation methods, with better prediction accuracy, may allow design of lighter rotors without compromising rotor integrity.

The aim of the project is to develop novel methodologies for assessing overspeed capabilities of new disc alloys. This will involve new rig designs and test capability as well as development of advanced correlations to enable transferability to component designs. The main benefits of the project are:

- Development of methodology to carry out small-scale overspeed burst tests will allow for improved and more cost effective characterisation of materials failure behaviour.
- Improved correlations and failure criterions will allow for better exploitation of material capability leading to optimised designs for both weight and life.
- Reduced cost and wastage through the use of small scale tests will have associated environmental benefits.
- Production of small-scale test disc doesn't interrupt production output.
- No dummy blades are required for small-scale test reducing lead time and cost.

The main tasks can be described as follows:

- Design of a representative small-scale spin test for hoop burst overspeed testing.
- Commissioning of test rig and proof of concept tests.
- Analysis of rig tests and development of the overspeed correlation to read across the results from a small-scale to a full sized component.

2. Scope of work

Tasks		
Ref. No.	***Title – Description***	***Due Date***
1	Design of a representative small-scale spin test for hoop burst overspeed testing	T0+18 months
2	Commissioning of test rig and proof of concept tests	T0+24 months
3	Analysis of rig tests and development of the overspeed correlation to read across the results from a small-scale to a full-scale disc	T0+36 months

Task 1

The main objective of this task is to identify suitable design solution for a small-scale disc for hoop burst overspeed testing. The design of test vehicle shall be representative of a real full-scale component and allow for suitable read across of a strength limit. Furthermore, the small-scale test, supported by extensive FE modelling, should provide basic understanding of the failure mechanism observed in the disc when subjected to overspeed conditions. The main factors affecting the integrity of a disc component shall be identified. This includes the effect of:

- Peak values of stress and strain
- Stress and strain distribution and gradients
- Amount of creep and plasticity
- Stress bi-axiality
- Strain rate effects

As there is no prior experience with running small-scale overspeed tests for hoop burst, a validation exercise is required to identify any potential issues associated with the new methodology. The material utilised shall be a nickel based alloy consistent with a type utilised by the aero engine manufacturers to allow comparison with a full-scale rig test. The main objective of this validation exercise is to demonstrate the suitability of small-scale testing for hoop burst by generating representative failure mechanisms observed in full scale tests, i.e. failure occurs at similar levels and distribution of stress and strain. In order to allow for that comparison, detailed and accurate nonlinear FE models, for both small-scale and full-scale rig tests, need to be developed. To ensure accuracy of the FE models, validation and definition of material models may be required. This includes:

- Validation of the creep and plasticity models
- Development of accurate yield and failure criteria capable of capturing bi-axial stress field
- Bi-axial specimen testing required to calibrate yield and failure criteria

Task 2

The main objectives of this task are to develop and commission a rig facility capable of small-scale overspeed testing for hoop burst, as well as to conduct a validation test designed in Task 1. The entities involved in this task will possess and develop the following capabilities:

- Spin test facility able to accommodate a small disc with an outer diameter of around 110mm, which will be spun to failure. Therefore, the facility should be equipped with a suitable containment ring to prevent release of high energy debris.

- Testing at high rotational speeds up to 120,000 RPM, temperatures up to 700°C and capability for the test to be conducted under vacuum conditions.
- The facility should utilise sufficient instrumentation to demonstrate that the specified temperature and speed have been achieved and remain stable throughout the whole test.
- Speed and temperature control should provide accuracy within ±100RPM and ±5°C of the defined nominal value.
- The rig shall be equipped with vibration monitoring, to ensure that no issues associated with the rig design and/or build (e.g. rotor-dynamic instabilities, assembly modes, local feature excitations, etc.) occur during the test.
- Real-time displacement measurement capability shall be utilised to measure rim radial growth and rim axial deflection throughout the test.
- Real-time strain measurement, via strain gauges or high speed cameras, to allow validation of the FE models.

A reasonable quantity of disc material and material specification will be provided by Rolls-Royce to support this work. Machining and a preparation the disc for testing will be the responsibility of the consortium. Furthermore, as part of this task it will be required to design and manufacture all the auxiliary components and tooling required to attach the disc to the test assembly.

Task 3

In this task it will be required to post process the results of the rig test carried out in Task 2 and develop appropriate correlations to read across the strength limit to a full-scale component. This shall be supported by the results of the FE modelling carried out in Task 1, to allow validation of the small-scale testing method and provide input for development of the read across methods. The new approach shall consider the effect of creep, plasticity, stress concentration and bi-axiality. The following activities need to be carried out as a part of this task:

- Understand the failure mechanism of the small-scale disc and compare it with the one observed in the full-scale disc.
- Compare the nonlinear FE results of the small and full scale discs and correlate that with the results of the rig tests.
- Develop appropriate correlations to account for any differences between the full-scale and small-scale discs.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Work plan description on all tasks. (Tasks 1+2+3)	Document	T0+2
D2	Report on validation of the material models for overspeed assessment (Task 1)	Report Data	T0+8
D3	Report on FE modelling results of small and full scale overspeed tests (Task 1)	Report,	T0+16
D4	Report on the commissioning of the test facility (Task 2)	Report,	T0+18
D5	Post-test report presenting the results of the small-scale overspeed test, including failure investigation (Task 2)	Report,	T0+24
D6	Report on validation analysis and read across methods (Task 3)	Report,	T0+34

Milestones			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Work plan agreed (D1)	Review	T0+2
M2	Identification and demonstration of appropriate modelling methods for small scale disc design (D2)	Review	T0+6
M3	Presentation of FE modelling results of small scale overspeed test (D3)	Review	T0+14
M4	Demonstration of the capabilities of the spin test facility (D4)	Review	T0+16
M5	Presentation of the overspeed test results (D5)	Review	T0+22
M6	Identification of appropriate read across methods (D6)	Review	T0+26
M7	Final report (D1-D6)	Report	T0+36

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

This package of work will require expertise in field of mechanical and materials engineering as well as mechanical testing.

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:

- Advanced nonlinear FE modelling and method development skills
- Material model code development skills
- Experience in high speed and high temperature rig testing
- Capability for bi-axial specimen testing
- Manufacturing capability for tooling and auxiliary components
- Material condition and failure assessment skills

The intention of this project is to obtain approval from the relevant airworthiness authorities, on the validity of the methodology for use in integrity assessments. That is why the intelectual property derived as a part of this project will need to be shared exlusively with the relevant airworthiness authorities.

VIII. Fuel Injector Coking

Type of action (RIA or IA)	IA		
Programme Area	ENG - WP6 – VHBPR for large engines		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	1000 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	36 months	**Indicative Start Date**[52]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-ENG-03-14	**Fuel Injector Coking**
Short description (3 lines)	
The aim of the project is to develop in-depth understanding of fuel coking phenomena based on a combination of rig testing and simulations. Both flowing and stagnant fuel coking regimes will be investigated as well as propensity to fuel ingress of industrially relevant fuel injectors. The research here proposed will directly support ultra-high bypass ratio engine design concepts, as these are usually leading to an increased amount of heat transfer to the fuel circuit.	

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

1. Background

Modern designs for civil applications are driven by better performance, safety and reliability at low operating costs. Historical trends show how engine performance parameters have evolved with time; these include the bypass ratio (BPR), the core overall pressure ratio (OPR) and turbine entry temperatures (TET). The drive for high BPR in order to improve the engine's propulsive efficiency also calls for an increased TET in order to achieve the required specific thrust. This leads to very high bypass ratio designs (Very High By-Pass Ratio, VHBPR), which will feature lean burn combustor design concepts. The ITDs will lead the design and development of VHBR technologies for middle of market (WP5 of Engine ITD) and VHBR engine demonstrator (WP6 of Engine ITD) for large engine market.

One drawback to increasing cycle temperatures is the influence of flame temperature on oxides of nitrogen (NOx) emissions which cause serious health concerns and contribute to global warming and ozone depletion. One additional implication of high operating temperatures is the thermal stressing of the fuel which is used as a heat sink to cool some aircraft systems such as the oil system and to reduce specific fuel consumption. This is particularly true for geared turbofan engine architectures (VHBPR), due to the increased need to cool the oil used in the gearbox connecting the LP shaft to the slowly rotating fan. The significant amount of heat sunk into the fuel can cause the deposition of carbonaceous materials within the fuel nozzle; the term coking is generally used to describe this phenomenon. The occurrence of blockages caused by coke formation may result in uneven fuel sprays or localised burning (high temperature spots), which may lead to mechanical failure or simply have detrimental effects on the engine. This is of particular concern in a modern lean burn combustion system where fuel passages, arranged in two separate circuits (i.e. main and pilot), are often designed as an integral part of the fuel injector heat management.

While more heat is bound to be dumped onto the fuel, the increased cycle efficiency provided by the UHBPR concept will lead to decreased fuel flow levels at a given thrust, which will make the fuel coking problem more serious.

The aim of this proposal is to significantly enhance our understanding of the coking process within representative fuel injector geometries and at a variety of flow regimes. It will also look into the effect of surface roughness, to enable derivation of design rules for additive manufactured fuel injectors. Eventually the experimental work will be used to validate and verify computational methods for predicting carbon formation. It is expected that this research will support development of UHBPR technology in a substantial manner.

2. Scope of work

Tasks		
Ref. No.	***Title – Description***	***Due Date***
1	Management	T0+36
2	Flowing fuel coking	T0+36
3	Development of reaction mechanisms for CFD prediction of coke deposition rates	T0+36
4	Stagnant fuel coking	T0+30
5	Fuel ingress	T0+24

Task 1: Management

Organisation: The partners shall nominate a team dedicated to the project and shall inform the consortium programme manager about the name/names of this key staff.

Time Schedule & Workpackage Description: the partners shall work 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: three progress reports shall be written over the duration of the programme. For all work packages technical achievements, time schedule, potential risks and proposal for risk mitigation shall be summarised.

Regular coordination meetings shall be conducted via telecom where appropriate.

The partners shall support reporting and agreed review meetings with reasonable visibility on their activities and an adequate level of information.

6-monthly face to face review meetings shall be held to discuss progress.

Task 2: Flowing fuel coking

Using fuel as a heat sink in modern gas turbine applications is a common solution. Rising core cycle temperatures however have led to complicated thermal management strategies which in turn are limited by the thermal stressing of fuel. It is known that at temperature ranges of up to 260°C, aviation fuel is susceptible to thermal degradation due to a chemical process called autoxidation as a result of the presence of dissolved oxygen. It is of high importance to be able to understand this phenomenon and the factors affecting it in order to be able to determine design rules to aid fuel spray nozzle designs.

The aim of this task is to use thermal stability rigs capable of replicating a typical aviation fuel system in order to investigate the autoxidation phenomenon by deriving detailed or pseudo-detailed reaction mechanisms. The test section shall be capable of accepting complex geometries in order to match features of actual fuel passages.

A large scale facility shall be used that is capable of matching engine representative flow regimes; these should include fuel residence time, Reynolds number and wall and fluid temperatures. Particular emphasis shall be put on the capability of the rig to reproduce the thermal stressing history of the fuel as well as to test engine representative fuel injector components. As such, the rig shall be of Technology Readiness Level (TRL) 5. Figure 1 provides a schematic of the type of rig to be used.

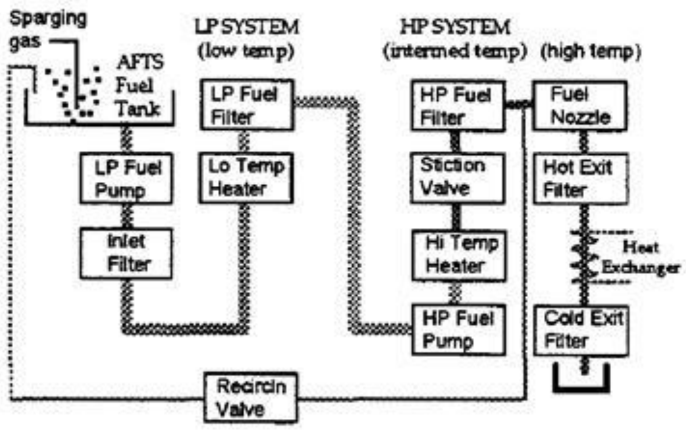


Fig. 1: schematic of a typical large scale TRL5 fuel thermal stability rig

The rig must at least be capable of running at the conditions specified in table 1.

Test time	75	hr
Fuel flow rate	23	l/hr
LP system pressure	50-200	psi
LP bulk fuel temperature	50-180	deg C
HP system pressure	500	psi
HP bulk fuel temperature	180	deg C

Table 1: typical operating condition of the thermal stability rig

Achieving these conditions on representative fuel passage geometries will allow characterising the coking behaviour in real fuel injectors.

Typical aviation fuels (made of a composition of paraffins and aromatics) shall be investigated including effects of pre-stressed fuel on the coking mechanism. It is expected that small scale rigs will be used as well. In addition to the classical Jet Fuel Thermal Oxidation Test (JFTOT) method (standard EI323), thermal stability shall be assessed in a rig able to run at turbulent flow conditions (standard EI482).

Figure 2 shows a schematic of this type of rig, which provides so-called HiReTS peak and total numbers.

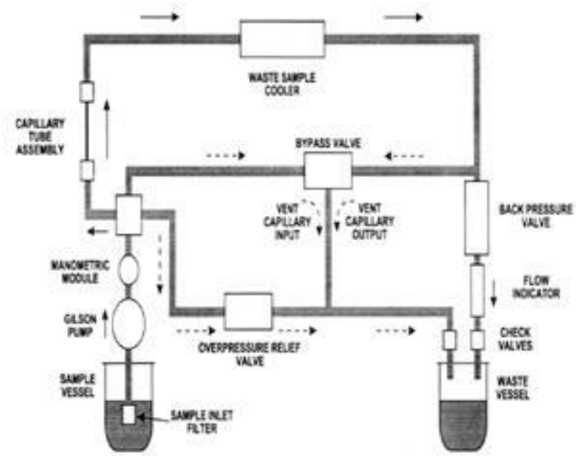


Fig. 2: schematic of a typical turbulent small scale rig (EI482 standard)

Results from the small turbulent thermal stability rig shall be correlated against results produced with the large scale thermal stability rig outlined in figure 1. Furthermore, some investigation on alternative aviation fuels would be beneficial. It would be desirable, but not mandatory, experimentally to explore impact of synthetic antioxidants, trace metals and especially reactive sulphur on coke formation. When testing with one type of fuel, in order to rule out the potential impact of fuel variability on test results, all tests shall be performed with the same batch of fuel, which in turns calls for a capient fuel storage system. The formation of coke will be checked and quantified by measuring changes in effective area, by burning off the carbon and where appropriate by sectioning the test pieces and measuring the deposit thickness. Measurements will also be taken of the metal and fuel temperature to monitor the thermal behaviour.

The effect of surface roughness is also of high importance. Novel manufacturing techniques based on additive methods are being investigated to aid future designs of combustors and fuel spray nozzles. The surface finish and surface treatment of fuel passages may have a significant effect on the deposit mechanism. It is therefore of timely importance to investigate the effect of surface roughness on coking formation resulting from novel manufacturing techniques (e.g. Direct Laser Deposition, or DLD). The large scale fuel thermal stability rig outlined in figure 1 shall be employed to assess coke formation by comparing deposition rates in fuel passages manufactured by conventional means and by novel manufacturing methods. Correlations will be derived to characterise the impact of the increased roughness usually associated with additive manufacturing techniques on coke formation. A total of 24 different tests shall be carried out on the large scale facility. The ITD will provide information enabling the manufacturing of pipework representative of actual fuel injector passages.

Task 3: Development of reaction mechanisms for CFD prediction of coke deposition rates

Some progress has been made in the last decade or so in the development of reaction mechanisms aimed to predict the coke deposition rates in a RANS CFD framework. These are usually skeleton mechanisms including a small number of reaction steps for the estimation of deposition rates. While the approach looks encouraging, more research is required in the development of computationally affordable reaction mechanisms able to provide reliable information at design stage. The main objective of this task is the derivation of reduced reaction mechanisms applicable to the operating conditions of interest in terms of temperature, pressure and Reynolds number. Such mechanisms would enable prediction of the deposition rates and their evolution over time (i.e. the temporal history of deposit thickness). Validation shall be performed based on the experimental results obtained in task 2. It is envisaged that some kind of optimization of the kinetic rates would be required to obtain a good match against experimental data. A range of sensitivity studies shall be carried out against relevant operating parameters. In particular, temperature, concentration of oxygen dissolved in the fuel as well as the impact of surface roughness shall be investigated. It is expected that a sticking probability model will be required for derivation of deposition rates. Investigations on the effect of tracer species in the fuel (e.g. S, Mg) on coking would be considered useful, albeit not strictly necessary. As far as the controlling areas are concerned, a moving mesh approach shall be investigated to model the growth of coke on the walls.

While development and validation of the approach will be based on measurements taken in task 2, in the end the numerical methods will be applied to an industrial injector geometry and results compared with existing service data to be provided by the ITD. All model development and simulations will be performed using the ITD in-house CFD code, for which access will be provided, based on the terms and conditions to be defined in the Implementation Agreement. An important requirement to be met is the computational affordability of the reaction mechanism. While detailed mechanisms may be used to start with, the final coking mechanism must be sufficiently small (~30 reaction steps) to enable its utilisation as part of the design process.

Task 4: Stagnant fuel coking

Lean burn combustors rely on internally staged fuel injector design concepts to comply with the stringent emissions regulations. In such applications two fuel circuits can be used: a pilot and a main, which is introduced at higher power. This added complexity of the fuel spray nozzle design adds to the risk of coking within the passages should pockets of fuel become stagnant within a potentially hot and oxygen-rich environment.

There are two aims to this task. The first is an investigation of the effect of dissolved oxygen in stagnant fuel, which would be of concern in some parts of the fuel system. The second relates to fuel passages in particular, because of the need to stage out the main fuel circuit at mid- to low power conditions with the risk of small pockets of fuel becoming stagnant in a high temperature and pressure environment.

It is expected that propensity to coke formation will be obtained using a small scale rig enabling testing at engine representative pressures and temperatures with and without air headspace (up to 7 bar and

220 deg C). Correlations will be derived to define at which conditions coke forms in a stagnant environment.

Task 5: Fuel ingress

This work aims to understand the physical processes behind fuel ingress into fuel injector tertiary cavities. Right after staging off of the main, most of the fuel will drain off the fuel passages. However, for certain operating conditions and injector positions small amounts of fuel can linger in the fuel passages. As a result, some of the fuel can drip into the injector tertiary cavities. Subsequently, such fuel will be exposed to high temperatures, therefore leading to coke formation in the tertiary cavity. In turn, this will either cause damage to the fuel passages (e.g. the feedarm) due to carbon jacking or simply create a region of high heat flux to the passages, where coking can then occur. The experimental work here proposed shall look into the causes of the ingress into the tertiary cavities within two fuel injector geometries that will be provided by the ITD. The first one will be a simplified one, the second one will be a more realistic representation of an actual fuel injector. A sniffing equipment made of a hypodermic pipe will be used to measure unburnt hydrocarbons in tertiary cavities in a rig that will be operated at temperature conditions up to 250 deg C. The rig shall allow orienting the fuel injector in different positions to mimick the behaviour of different locations with respect to the top dead centre.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1.1	Year 1 management report	Report	T0+12
D1.2	Year 2 management report	Report	T0+24
D1.3	Year 3 management report	Report	T0+36
D2.1	Effect of different flow regimes using simple geometries & applied to representative geometries	Report	T0+12
D2.2	Effect of surface roughness	Report	T0+24
D2.3	Effect of pre-stressed & alternative fuel	Report	T0+36
D3.1	Reaction mechanism validated on simple rig geometry	Report	T0+14
D3.2	Reaction mechanism validated on complex rig geometries	Report	T0+26
D3.3	Sensitivity studies completed	Report	T0+30
D3.4	Simulation of industrial fuel injector	Report	T0+36
D4.1	Effect of dissolved oxygen on stagnant fuel coking	Report	T0+18

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D4.2	Stagnant fuel coking in high pressure and temperature environment	Report	T0+30
D5.1	Fuel ingress investigation	Report	T0+24

Milestones			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Kick off meeting	Review	T0
M2	M6 review meeting	Review	T0+6
M3	M12 review meeting	Review	T0+12
M4	M18 review meeting	Review	T0+18
M5	M24 review meeting	Review	T0+24
M6	M30 review meeting	Review	T0+30
M7	M36 review meeting	Review	T0+36

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

- In-depth experience on factors affecting aviation fuel thermal stability
- Availability of fuel thermal stability rigs. In particular, a large scale TRL5 fuel thermal stability rig able to reproduce typical engine conditions as detailed in table 1 is mandatory. The rig must be capable of testing actual fuel injector components. Furthermore, a JFTOT rig (EI323 standard) and a small turbulent flowing rig (EI482 standard) must be available.
- Capability of running a large number of tests with the fuel flows and test duration times indicated in table 1 using the same batch of fuel in order to rule out fuel variability effects on test results
- Experimental experience in running aviation fuel thermal stability tests for the detection and quantification of carbon deposits based on fuel thermal stressing history typical of a large turbofan engine
- Understanding of novel manufacturing methods and proven record on quality of surface finish effect on deposition mechanisms
- Hands-on proven experience in numerical methods for the prediction of coke deposit formation, with emphasis on derivation of reduced reaction mechanisms for coking deposition rate and its temporal variation

IX. Engine Control System

Type of action (RIA or IA)	IA		
Programme Area	ENG – WP7.6 [Light weight and efficient Jet-fuel reciprocating engine]		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	500 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	18 months	**Indicative Start Date**[53]	Q2 2017

Identification	Title
JTI-CS2-2016-CFP04-ENG-04-06	**Engine Control System**
Short description (3 lines)	
Design and manufacture an engine control system prototype to mainly drive a mechanical injection system.	

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

1. Background

The “compression ignition” engines burning the aeronautical kerosene/Jet fuels, otherwise called “diesel” engines, can reduce fuel burn by 50% to 65% compared to a small turbine engine, and by 30% to 50% compared with an avgas engine. These points bring both an environmental benefit and a drastic reduction of operating costs. Replacement of an Avgas piston engine by a diesel engine brings a high cumulative benefit of fuel burn and fuel price reduction.
Jet fuels are also worldwide available, have a low flamability and are lead free.

On the first generation of diesel engines, the weight penalties were, for a medium range mission, more or less compensated by the fuel weight savings, but with the new high power density diesel engines, the global weight balance can be favourable to diesel versus avgas engines, even for short flight legs. Thus, it provides an additional benefit of payload for a medium range mission.
A similar conclusion is obtained when new diesel engines and turbines are compared.
There are also additional benefits for the diesel engines as:

- The lower speed of rotation allowing important noise reduction, both inside (in the cabin) for passengers and pilot comfort, and outside for the community. This last point may allow the survival of airfields near cities and by consequence the development of the small aviation transportation market.
- Reduction of the number of levers (no mixture) for a simpler control by the pilot,
- Reduction of inspection and maintenance (no magnetos, no spark igniters ...).

Thus, the use of piston engines burning the affordable and worldwide available Kerosene fuel is a logical step to overcome these drawbacks. Airframers producing small airplanes create strong pressure to engine manufacturers to get their compression ignition power units more mature and certified with high performance.

2. Scope of work

The engine control system is a device to be integrated to a 6 cylinder engine in order to :

1. Basic function
    a. Avoid to exceed engine maximum limits. If limits are exceeded, a black box should remind the information
    b. Provide assistance to set a power
    c. Provide assistance for minimum limitation , or to act devices to increase margins.
2. Specific function
    a. Provide assistance for the engine start or inflight restart,
    b. Allowing special idle with only one engine bench running and capability to relight the other bench
    c. Allowing dissymetrical bench power in case of one engine bench malfunction,
    d. Including feather propellers (for twin engine aircraft),
3. Capable to be certified.

Pilot involvement. 3 options to be studied:

1. Mechanical system fully controlled by the pilot, in addititition to an EMU (Engine Monitoring System) providing assistance by adequate information to the pilot.
2. ECU (Engine Control Unit) :
    a. Option 1 – parallel configuration : In case of malfunction the pilot can switch to a second mode (mechanical)
    b. Option 2 - serial configuration: In case of malfunction the pilot can overide or/and switch off as convenient.
3. Fully ellectronic device with redundant ECU.

Tasks		
Ref. No.	**Title - Description**	**Due Date**
T0	*Organization preparation*	To
T1	*Specification*	To + 3 months
D2	*PDR with options seclection*	To + 6 months
D3	*CDR*	To + 9 months
D4	*Prototype available*	To + 15 months
D5	*Prototype tested on bench*	To + 18 months
D6	*Prototype tested on engine on ground*	To + 20 months
D6	*Prototype tested on engine in flyght (option)*	option

3. Major deliverables/ Milestones and schedule (estimate)

Milestones (M) / Deliverables (D)			
Ref. No.	Title - Description	Type(*)	Due Date
M1	*Kick Off*	RM/R	To
D1	*Specification*	RM/R	To + 3 months
D2	*PDR with option selected*	RM/R	To + 6 months
D3	*CDR*	RM/R	To + 9 months
D4	*Prototype available*	D	To + 15 months
D5	*Prototype tested on bench*	R	To + 18 months
D6	*Prototype tested on engine on ground*	R	To + 20 months
D6	*Prototype tested on engine in flight*	R	option

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

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

- Experience in 4 stroke diesel technologies,
- Experience in ECU/EMU or FADEC
- Experience in certification
- All partners should have experience in material, processes, simulation and testing,
- Experience in prototype manufacturing,
- Experience in prototype testing,
- Experience in test bench design and modification,
- English language is mandatory

6. Clean Sky 2 – Systems ITD

I. Very high brightness & compact full color display for next generation eyes-out cockpit products

Type of action (RIA or IA)	RIA		
Programme Area	SYS - WP Level 1 – WP1: Extended Cockpit		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	3800 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	36 months	**Indicative Start Date**[54]	Q2 2017

Identification	Title
JTI-CS2-2016-CFP04-SYS-01-03	**Very high brightness & compact full color display for next generation eyes-out cockpit products**
Short description (3 lines)	
The objective is to develop a new generation of emissive micro-displays with full color, very high brightness , low power and good form factor capabilities that will enable the design of ground breaking compact see-through systems for next generation Avionics applications.	

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

1. Background

Ground breaking solutions in future generation of cockpit such as windshield projection or advanced head worn solutions require a very large amount of optical power to remain usable in avionic sunlight environment. Moreover these micro-displays components - as well as the optical engine solution associated - have to present a compact form factor and a very good power optical efficiency to be easily integrated in cockpit solutions.

Each existing micro-displays solution suffers from either different issue when considered for the application:

- Color transmissive LCDs are limited by their very low light transmission. They are power consuming and have difficulties to achieve a very high brightness with full color capability in single display solutions. Moreover Backlighting module appears to be bulky due to the consequent volume of the thermal management system.
- System based on reflective LCOS micro-displays are bulky and heavy because they need a Polarising Beam Splitter (glass cube at display size or a little bigger), and are also difficult to use with high field of view and large pupil system.
- Micro mirrors and MEMS are also bulky to integrate in compact systems and not compatible with large pupil system. They might also be limited in resolution.

To save on volume, cost and power consumption and to facilitate the integration in the optical engine, it appears that micro-displays with emitting pixel elements are the best solutions.

OLED micro-displays are based on emitting pixel elements. They demonstrated very good optical properties and are, for the time being, the only component easy to integrate in a compact optical engines. But unfortunately OLED phosphorescent or luminescent materials cannot reach the expected level of brightness with a sufficient lifetime even for monochrome applications. For color displays where the surface allocated to each color is 1/3rd of the display surface, the problem is even more severe. Brightness at each single diode is multiplied by 3 thus reducing the lifetime by a factor of at least 6 which is not compatible with the application.

Some innovative solutions such as emissive micro-displays based on arrays of color LEDs structured on sapphire wafers and coupled to a silicon backplane active matrix should be able to provide more than 1.000.000cd/m² at a compatible size and pitch with almost no limitation on life time (inherited from the maturity of the solid state GaN LED technology). Such a solution will allow the design of very compact solutions while keeping a significant margin in brightness for future Avionics Eyes Out Applications.

When this development reaches its objectives, these micro-displays technology will also be used in large public markets for both automotive Head Up Displays and also, more widely, for consumer projectors products, which should extend significantly in the next few years.

2. Scope of work

The final objective of this topic is to deliver monochrome and full color micro-display prototypes for their integration in an avionic windshield projection demonstrator.

Although the main requirements for these single colour and full colour prototypes are listed below :

- Maximum brightness : at least of 1.000.000 cd/m² and possibly 10.000.000 cd/m²
- Targeted Resolution : 1920x1200 pixels (WUXGA)
- Die Size ~ 1'' diagonal (inducing a Pixel pitch ~ 8-10µm)
- Spectral BandWidth < 50 nm
- Selected half angle of emission ~ 30°
- Video Frequency Refresh : at least 50-60Hz
- Intra-scene Contrast > 500:1
- Targeted micro-display power consumption < 0,1 W per output lumen
- Reduce set of defective pixels and no visual defects altering the image displayed.
- Angular and spatial uniformity of micro-display brightness and spectral bandwidth.
- Component Life-time up to several thousands of hours.

It has to be understood that 1million Cd/m² for colour and 10 million cd/m² for single colour displays are the ultimate requirements of the project. They are far beyond the possibilities of the existing emissive technologies today. A first target of 1million cd/m² for single colour displays and 100 kcd/m² on full colour displays would already represent a significant breakthrough enabling the application in the cockpits. The detailed target specification will be agreed between the SYS ITD members and the applicant in the first phase of the project, based on the objectives of the applicant to be described in its technical proposal.

The work breakdown and deliverables proposed here below to achieve this goal may be rearranged by the partners to facilitate their workflow.

Tasks		
Ref. No.	***Title – Description***	***Due Date***
WP1	Development of monochromatic emissive materials and optimisation of their optical efficiency.	M18 green M24 (red)
WP2	Development of array structuration process or deposition process.	M24
WP3	Design of color Active Matric backplane compatible with monochromatic applications.	M18
WP4	Research of solutions for high brightness full color applications with optimized optical efficiency.	M26
WP5	Design and manufacture of emissive monochrome green micro-display prototypes	M28
WP6	Design and manufacture of emissive full color micro-display prototypes	M32
WP7	Development of micro-display mother-Board and complete characterisation of developed components	M36

a) **WP1 : Development of monochromatic emissive materials and optimisation of their optical efficiency.**

The objectives of this work package are to deliver solutions for monochromatic emissive stacks or components (Green, Blue and Red) in specified wavelength ranges. They have to generate at least more than 1 million of lux while keeping a sufficient life time for avionics applications. The spatial and angular brightness uniformity, bandwidth selectivity and bandwidth angular and spatial uniformity of these materials will also be tightly monitored in this WP. Partners should develop and manufacture either raw materials or sources for electro-optical components to be used in WP2 or WP4 to build the arrays of electro-optical elements both single color and full color. It is also the purpose of this WP to characterize the performance of each solution.

This WP should benefit from the experience of Advanced Research Institute with a strong background on emissive technologies and materials and on their own industrial experience to offer solutions that can be produced on industrial equipments.

Several iterations of materials might be needed before the delivery of full color electro-optical components, based on proposal of WP4 – compatible with pixel array structuration solutions in WP2 - and bonded to silicon in WP5 to achieve the expected performances of the micro-displays.

This WP will allow to converge on the detailed requirements for the components after iterations.

b) **WP2 : Development of array structuration process or deposition process.**

The objective of this work package is to develop the process (material array structuration or deposition) to produce an organized array of pixels with the high efficiency emissive materials of WP1 at the targeted pitch and brightness. This work will be done for each monochromatic emissive material (Green, Blue and Red) designed in WP1. Once again the spatial and angular brightness uniformity, bandwidth selectivity and bandwidth angular and spatial uniformity of these materials will be monitored in this WP but also the cross-talk between pixels in order to ensure high contrast capability of the matrix. The capacity to design pixels within a targeted angular selectivity will also be a key driver to ensure the efficiency of the complete optical engine.

It is also possible that color definition is only achieved at this stage based on materials of WP1 and architectures of WP4.

The WP will pay a special attention to the compatibility of the solutions with available industrial equipments. The target there is to demonstrate a solution that can be manufactured at a reasonable cost with the expected performances and an acceptable number of defect per cm² (<1ppm).

c) **WP3 : Design of a color Active Matric backplane compatible with monochromatic applications.**

The objective of this work package is to design the specific active matrix backplane at the specified pitch and targeted resolution (cf. WP6 & 7) to drive independently each pixel of the array of emissive optical elements supplied by WP2 at a given video frequency to deliver the requested number of grey levels on the pictures.

There are two kinds of requirements for the silicon. First, the CMOS chip specification should be able to provide voltage and current to each pixel cell to display pictures of the highest quality to the user. This task might include (non exhaustive list) designing a high speed digital interface to the system, designing digital to analogic converters to supply analogic information to the pixel elements, to compensate for non uniformity on the characteristics of electro-optical elements in the electrical design, to compensate for the drift of the optical performance of the pixels in operation or in temperature and to offer a high range of dimming. The design has to take into account the requirements of the system designer for the video interface, the environmental conditions and the optical performance of the system as well as the electro-optical characteristics of the optical elements provided by WP1 and WP2

Second, the integrated circuit has to be manufactured in a silicon foundry that is able to provide process adjustment of final pixel layers on the latest high voltage CMOS technology to enhance the performance of the electro -optical solutions and to enable a close electrical contact between the array of pixel drivers and the array of emissive pixel elements.

The active matrix should be compatible with different color applications at the same resolution.

It is believed that since the integrated circuit is coming from an operating silicon foundry, both design and processes can be manufactured in larger volumes.

It could be a good practise to test the solutions for the design of the integrated circuit on smaller volumes of products.

Note that partners may propose the design of a first "small backplane" prototype with a lower resolution in order to ensure to obtain all the characteristics of the final prototype.

d) WP4 : Research of solutions for high brightness full color applications with optimized optical efficiency.

The objective of this work package is to search for different solutions of stacks and / or pixel array organisation with their associated pixel array generation process in WP1 in order to provide 3 different colors at the pixel level at very high brightness (more than 1 million lux each) on the same active matrix. All the solutions proposed will then be sorted out and only the most promising ones - compatible with the targeted pitch (and other micro-displays specification from WP6) - will be prototyped and evaluated in order to select the solution for implementation of a full color micro-display in WP7. This work package is certainly the most advanced part of the topic since up to now very high brightness color solutions for emissive micro pixels do not exist.

e) WP5 : Design and manufacture of emissive monochrome green micro-display prototypes.

The objectives of this work package are - thanks to the work performed through WP1 to WP3 - to design, realise and characterise several prototypes of full functional monochrome green micro-displays compliant with the key specifications listed below:

- Maximum Brightness : at least of 1.000.000 cd/m² in green and possibly 10.000.000 cd/m²
- Targeted Resolution : 1920x1200 pixels (WUXGA)
- Spectral BandWidth < 50 nm
- Die Size ~ 1'' diagonal (inducing a Pixel pitch ~ 8-10µm)
- Selected half angle of emission ~ 30°

- Video Frequency Refresh : at least 50-60Hz
- Intra-scene Contrast > 500:1
- Targeted micro-display power consumption < 0,1 W per output lumen
- At least 255 levels of gray and possibly 1023 levels for gamma correction.
- Reduce set of defective pixels and no visual defects altering the image displayed.
- Angular and spatial uniformity of micro-display brightness and spectral bandwidth.
- Component Life-time up to several thousands of hours.

Partners should pay a special attention to the integration of the electro-optical solution on the active matrix which requires a very high density of electrical contacts with an extremely good yield (defect rate <1ppm) compatible with the avionics environment.

The tasks performed in this work package must also include the bonding of the component to a specifically designed and manufactured daughter board and all the mechanical, optical and environmental packaging (including thermal management) required for a proper use of these prototypes at the system level.

f) <u>WP6 : Design and manufacture of emissive full color micro-display prototype.</u>

The objectives of this work package are - thanks to the work performed through WP1 to WP3 and using the full color matrix array solution selected in WP4 - to design, realise and characterize several prototypes of full functional color micro-displays compliant to the key specifications listed in WP5 expect those listed below:

- Maximum Brightness : at least of100.000 cd/m² in white and possibly 1.000.000 cd/m²
- 255*3 levels for each color.

An intermediate step of a bi-color micro-display prototype using a couple of specific very close wavelengths should also been realized to implement a specific avionics functionality.

The concern on the integration of the electro-optical solution on the active matrix is even more severe on a full color array.

The tasks performed in this work package must also include the bonding of the component to a specifically designed and manufactured daughter board and all the mechanical, optical and environmental packaging (including thermal management) required for a proper use of these prototypes at the system level.

g) <u>WP7 : Development of micro-display MotherBoard and complete characterisation of developed components.</u>

The objectives of this work package are first of all to design and manufacture an "evaluation board" that will be used to perform the integration of the micro-display component video capability. This evaluation board should allow to plug the micro-display daughter board using (or not) a flex.

The other goal of this work package is, after the basic device characterization performed on WP5 & WP6, to conduct here - at a system level point of view - a complete set of measurements of electrical, optical (static and dynamic) and environmental performances what will assess the component compliance with all the requirements listed by the Systems ITD at the beginning of the project.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D1.1	First macro-pixel structure of green emissive material with characterization report		M12
D1.2	Optimized single macro-pixel structure of green emissive material with characterization report.		M18
D1.3	Optimized single macro-pixel structure of red emissive material with characterization report.		M24
D1.4	Optimized single macro-pixel structure of blue emissive material with characterization report.		M24
D2.1	Report on optimized matrix array generation process using WP1 materials and key requirements to the development of the active matrix		M18
D2.2	Prototype of passive monochrome green array of pixels with characterisation report.		M24
D3.1	Active Matrix Backplane requirements report		M5
D3.2	WUXGA Active Matrix Backplane chip design report (ready to manufacture)		M17
D4.1	Report on the comparison of technologies for the high brightness full color array with optimized optical efficiency		M26
D4.2	Prototype of passive full color array of pixels with characterisation report.		M30
D5.1	WUXGA Active matrix backplane manufactured with wafer-level test report		M22
D5.2	Full functional WUGXA monochrome green device packaged on its daughter board		M28
D6.1	Full functional WUGXA dichromic green device packaged on its daughter board		M30
D6.2	Full functional WUGXA full color device packaged on its daughter board		M36
D7.1	Full functional driving motherboards for the color and monochrome WUXGA displays prototypes		M24
D7.2	Complete Report on green WUXGA monochrome display performance.		M32
D7.3	Complete Report on green WUXGA monochrome display performance.		M36

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***

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

Skill 1: Raw material and processes

Whether the solution for very high brightness micropixels, there will imply a strong request for innovation on the raw materials and processes for the development of the most efficient devices. The partners should demonstrate that they have the knowhow and the background to push display or lighting materials and processes to their limits either in size or in power efficiency and quality in order to achieve expected performances at each single pixels with a good uniformity. They also have to demonstrate that they can rely on Advanced Research Institutes that are able to monitor the theoretical operation of the materials involved, as well as the modelling of the improvement or the innovation in progress. The advanced research institutes that are active in the field of display materials and components are thus welcome in the research program.

Skill 2: Optical effect for high brightness pixel array

The project is looking for an electro-optical solution for very high brightness micro pixels. This very specific skill is the mastering of the technology (design and process) to get a very high luminous output out of high quantity of micro-elements located next to each others. The partners should demonstrate the control of an optical technology that can provide the expected amount of light on the projected pixel size which is also compatible with the integration into an array of more than 2 million elements without any problems such as optical or electrical crosstalk, uneven power or brightness distribution, a bandwith down to the pixel level, compatible with the thermal management capability of the system but which is also able to achieve colors, a low defect rate (0.1ppm), a good contrast, a fast response time and wide optical dynamic range in the operating temperature range and in all avionics operating conditions.

What is expected is a very good understanding of the limitations of the different existing technologies in order to push their performances into new limits. It has to be supported by new ideas, proofs of concepts and validated intellectual property rights. The partner will use its strong relations with raw materials suppliers providing the elements according to the requirements of the application and with advanced research institutes on the other end, providing the theoretical understanding, the modelling and low level prototyping capability and to support the innovation process. These advance research institutes are also welcome in the program.

What is also expected is the access to high technology solutions to build very advanced optical components such as clean rooms, lithography equipments, coating and etching machines able to provide a very high density of components. The partner in charge of the optical effect should demonstrate its industrial capability in providing the different samples of high brightness electro-optical arrays which will be needed along the project development but also in demonstrating his business plan and his strategy for the future growth of the technology.

Skill 3: Active matrix pixel array on silicon design and manufacturing

It is highly probable that the microdisplay will request the design of a very specific integrated circuit such as an array of isolated pixel elements which is called an active matrix display. Whatever the technology, there will be requirements at the pixel level on electrical design and on pixel materials to interface electrically, optically, chemically and mechanically with the electro-optical element or effect. Two partners or two competences are needed there: the first is the capability to understand the electrical operation of the optical element and to

design the circuit able to drive it in all operating conditions to provide the best picture quality, the second deals more with material implementation on chip to achieve the most efficient integration of the electro-optical element in order to achieve 100% yield and optimal optical efficiency.
Each pixel of the active matrix is connected to at least a row and a column that are driven by integrated circuits that are connected to the video input. Electrical design of the interface between the outer world and the rows and the columns is already strongly related to system design and to microdisplay performance. Chip operation should be perfect in all operating conditions in the aircraft: day or night, cold or hot, Radio On or Off…
The first competence is a silicon design house with a good knowledge on pixel arrays while the second skill is a silicon foundry with process development and advanced design rules capability since the dot clock of the chip will be close to 200MHz with 8bits digital to analog conversion on chip.

Skill 4: Integration of optical and electrical technologies
The integration of the electro-optical technology on the silicon chip will request specific equipments or processes compatible with both types of components: the silicon chip and the array of electro-optical elements. It can be either a vacuum deposition chamber to coat each layer of the optical element on the pixel electrodes on silicon or a bonding maching to connect the optical part of the pixels to each electrical circuit on the silicon chip or another machine specific to the optical effect. The integration technology should offer a 100% yield without creating losses in the optical or electrical path and strong enough to be compatible with the environmental conditions of the aerospace industry. Although technologies for the optical effect or silicon technologies are well known, integration technology is very unique and dedicated to the application. It is definitely one of the critical step of the project.
The partner should also have the capability to implement the most appropriate packaging technology for the device under development to manage both electrical, optical and thermal operation of the micro-display in the system.
All means used in the project to manufacture the prototypes should be available for production in an industrial environment or should have a plan covering their development for an industrial application

Skill 5: Assessment of microdisplay optical performance
Capacity and means necessary for a classical optical testing of the microdisplays.

II. Validation tests of electromechanical actuators and its dedicated control units at TRL 6 level

Type of action (RIA or IA)	IA		
Programme Area	SYS – WP3.2		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	732 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	24 months	**Indicative Start Date**[55]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-SYS-02-22	**Validation tests of electromechanical actuators and its dedicated control units at TRL 6 level**
Short description (3 lines)	
This call will cover software and complex hardware certification of ECUs and manufacturing of electromechanical actuators for innovative flight control equipment to be used in the flight tests. The systems will have to be compliant with aerospace certifiable requirements, since the intention is to obtain a permit to fly.	

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

1. Background

The electromechanical actuators developed within the frame of CleanSky II are intended to be used for the actuation of Aileron, Spoiler, winglet tab and flab tab control surfaces. The main objective is to achieve a sufficient Technology Readiness Level so as to obtain a permit to fly in the FTB2 demonstrator of the Regional Aircraft.
The activities under this Call for Proposal are aimed to manufacture the electromechanical actuators for the in flight tests activities and to test and certify the ECU hardware and software.

HARDWARE AND SOFTWARE CERTIFICATION (SPOILER AND AILERON)

ECU hardware and software for flight units shall be considered as flight HW/SW and require full certification in accordance with the applicable requirements of the Civil Airworthiness Authorities (FAA, JAA) for equipment to be used in aircraft being certified under FAR Part 25 and JAR 25.
Since ECU development is not within the scope of this call, partner activities will be performed from the already implemented HW and SW. Design process has been carried out according the applicable standards and the partner will have to validate that the resulting HW and SW comply with all the necessary requirements to achieve the requested assurance level. This process may result in modifications to be implemented in the existing HW/SW and cooperation with ECU developers may be required.
The partner shall state the applicability and conformance of the HW/SW to the functional, performance and safety requirements in the Declaration of Design and Performance (DDP) or Certificate of Compliance.
As a reference, the preliminary requirements for the Electronic Control Unit are described in the following paragraphs:
The Electromechanical actuators for aileron and spoiler shall be position controlled by an A/C equipment similar to other servo actuator control units (ACE´s). The ACE´s will command the ECU speed parameter (actuator extension and retraction rate). The surface position control will be performed by the ACE´s by using the position feedback data.
The ECU is in charge of accommodating all signals (including power input, if applicable) and implement the necessary network protection (upstream and downstream the ECU). It is also responsible for performing the control of the parameters that the actuator is reporting during all operations (and all operational modes). The ECU also reports to the A/C the parameters requested for a normal control loop closure.
The ECU will receive commands in terms of speed rate and torque limit and shall implement it in the actuator. This speed shall be implemented with the maximum precision achievable to ensure a smooth and accurate control of the Flight Control Surface. This requires a precise position measurement, an accurate torque and motor speed measurements, a fast and reliable integrated electronics to refresh commands with the necessary rate and a proper control loop closure in order to enable the A/C to close the surface position loop without any discontinuity or undesired effect.
The ECU shall also be able to implement additional logics of self-control.
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 discrete signals shall be totally segregated from ECU, wires, boards, harnesses, etc.
✓ If necessary, additional necessary interfaces for control and monitoring of the actuator for example: analogue signals, LVDTs, etc. These shall be sued for actuator internal purposes.
✓ Supplied with 270VDC.

The ECU shall have thermal protections to eliminate the fire risk under abnormal operation.

Level of integrity: 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.

HARDWARE CONSIDERATIONS AND EQUIPMENT CERTIFICATION REQUIREMENTS

For the electronic development and verification of the equipment, the partner shall apply **RTCA/DO-254 design assurance level** for the hardware in accordance with **equipment criticality, level A.** In case DO-254 is considered as not applicable, it shall be demonstrated by the Supplier and approved by the purchaser.

Additional guidelines and final Hardware requirements will be defined in the Technical Specification.

Partner activities shall cover:

- Planning
- Hardware Design Processes: the supplier shall ensure that the hardware design has been carried out such that all design decisions are adequately reviewed and documented to ensure that the design rational has been recorded and to demonstrate that all relevant design requirements have been captured and addressed.
- Validation process ensures that the HW requirements are correct and complete with respect to system requirements assigned to the hardware items.
- Verification Process: provides assurance that the hardware meets all the requirements. These activities include reviews, analysis and tests and a final assessment of the results.
- Configuration Management
- Process Assurance
- Certification Liaison

SOFTWARE CONSIDERATIONS AND EQUIPMENT CERTIFICATION REQUIREMENTS

The software shall be developed and qualified in accordance to **RTCA/DO-178 design assurance level** in accordance with **equipment criticality, level A.**

Additional guidelines and final Software requirements will be defined in the Technical Specification.

Partner activities shall cover:

- Planning
- Software Development Processes: the supplier shall ensure that the software development process has followed the model defined in chapter 5 of RTCA/DO-178. The Supplier shall have in place a software development environment that shall be reviewed for approval by the Topic Manager. This includes the standards, methodologies and tools for the management, development, implementation and testing of the software. The software development environment shall be described in the Software development Plan (SDP) for approval.

- Verification Process: the aim of the software verification is to detect and report errors that may have been introduced during development. Software Verification shall be in accordance with RTCA/DO-178 Chapter 6. In particular, the verification independence level shall be in accordance with tables A3 to A7. Verification include reviews, analyses and tests (including definition, procedures and test execution)
- Configuration Management: in accordance with Chapter 7 of RTCA DO-178. For each formal SW release a Configuration Index shall be delivered to the Topic Manager.
- Quality Assurance: Software Quality Assurance System in accordance to ISO 9001/ISO 9000-3 or equivalent shall be in place or shall be implemented by the applicant. The Quality Assurance process shall be in accordance with Chapter 8 of RTCA/DO-178. The QA records generated shall be available for review by the Topic Manager / certification Authorities.
- Certification Liaison

MANUFACTURING OF IN FLIGHT TESTS EQUIPMENT

Topic manager will provide sufficient details of EMAs and ECUs components in order to manufacture and assembly the units to be used for in-flight testing campaign. The number of units to be manufactured are summarized in table below.

Hardware Deliverables	
Aileron	4
Spoiler	6
Flap Tab	6
Winglet Tab	4
Backup Aileron Servo	5

First activity to be carried out by the partner will be the analysis of requirement. The partner will define the optimum manufacturing routes. Alternative materials and processes 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 approaches will be considered including novel manufacturing processes as additive manufacturing.

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 parts. The partner will support the Topic manager during the final assembly and tests activities.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
1	Analysis of Requirements	M2
2	Qualification Plan and Procedures	M3

Tasks		
Ref. No.	***Title - Description***	***Due Date***
3	Definition of manufacturing routes	M3
4	Alternative materials and processes to optimize manufacturing times, raw material use and environmental impact	M3
5	Qualification and Acceptance Tests	M16
6	Manufacturing of parts	M16
7	Support to assembly and test activities	M24

3. Major deliverables/ Milestones and schedule (estimate)

Hardware and software documentation shall be produced by the partner in accordance with RTCA/DO-254 and RTCA/DO-178 and the specified design assurance level. Full hardware/software documentation shall be available for the Topic Manager and Certification authority review.
As a minimum, the following deliverables shall be provided. Final set of document required will be agreed between the partner and the Topic Manager.

Hardware Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	HARDWARE PLANS DOSSIER: PHAC; Design Plan; Validation and Verification Plan; Configuration Management Plan; Process Assurance; Electronics Components Management Plan and Obsolescence Management Plans	Doc	M2
D2	HARWARE DESIGN STANDARDS DOSSIER: Requirements Standards; Design Standards; Validation and Verification Standards and Archive Standards	Doc	M4
D3. HARDWARE DESIGN DATA			
D3.1	HARDWARE DESIGN DOSSIER: HW Requirements; Conceptual Design Data; Detailed Design Data; Top-Level, Assembly and Installation Control Drawings; HW/SW Interface Data	Doc	M4
D3.2	COMPONENT DESIGN DOSSIER: Component Derating Rules; Temperature Range Selection; Second Source or Parts Evolution Validation Rules; Traceability Rules; Standardization Results; New Component Qualification Programme and Summary Report	Doc	M4
D3.3	COMPLEX COMPONENT DESIGN DOSSIER	Doc	M4
D4	VALIDATION AND VERIFICATION DOSSIER: Hardware Traceability Data; Hardware Review and Analysis Procedures; Hardware Review and Analysis Results; Hardware Test Procedures; Hardware Test Results	Doc	M6
D5	Hardware Acceptance Test Criteria	Doc	M6

Hardware Deliverables			
D6	Problem Reports	Doc	M6
D7	Hardware Configuration Management Records	Doc	M6
D8	Hardware Process Assurance Records	Doc	M6
D9	Hardware Accomplishment Summary	Doc	M6
D10 PARTS MANUFACTURING			
D10.1	Requirements analysis	Doc	M2
D10.2	Manufacturing plan and schedule	Doc	M3
D10.3	Risk analysis	Doc	M3
D10.4	Delivery of parts	Doc	M16

Software Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D11	SOFTWARE PLANS DOSSIER: PSAC; Development Plan; Verification Plan; Configuration Management Plan; Quality Assurance Plan	Doc	M2
D12	SOFTWARE DESIGN STANDARDS DOSSIER: Software Requirements Standards; Design Standards; Code Standards	Doc	M4
D13	SOFTWARE DESIGN DOSSIER: Requirements Data; Design Description; Source Code; Executable Object Code	Doc	M4
D14	VALIDATION AND VERIFICATION DOSSIER: Software Verification Cases and Procedures; Verification Results; Software Life Cycle Environment Configuration Index; Software Configuration Index	Doc	M6
D15	Problem Reports	Doc	M6
D16	Software Configuration Management Records	Doc	M6
D17	Software Quality Assurance Records	Doc	M6
D18	Software Accomplishment Summary	Doc	M6
D19	UMS Procedure	Doc	M6
D20	SOFTWARE TOOLS DOSSIER (if required): Tool Software Plans; Tool Software Design Standards; Design Data; Validation and Verification Data; Quality Assurance Records; Accomplishment Summary)	Doc	TBD

Milestones		
Ref. No.	***Title - Description***	***Due Date***
M1	Analysis of Requirements	M2
M1	Qualification Plan and Procedures	M3
M2	Definition of manufacturing routes	M3
M3	Qualification and Acceptance Tests	M16
M4	Manufacturing of parts	M16
M5	Support to assembly and test activities	M24

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

- ✓ Demonstrated experience (based on history) in development and verification of airborne complex electronic hardware according to RTCA-DO-254 for critical equipment or other civil or military equivalent standards.
- ✓ Demonstrated experience (based on history) in development and verification of airborne electronic software according to RTCA-DO-178 for critical equipment or other civil or military equivalent standards.
- ✓ 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 repair "in-shop" equipment due to manufacturing deviations.
- ✓ Capacity to assembly and testing complex aeronautical equipment.
- ✓ Capacity to support documentation and means of compliance to achieve prototype "Permit to Fly" with Airworthiness Authorities (FAA, EASA…).
- ✓ 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 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.

III. ECO-design based techniques and machinery for improved racking and distribution boxes

Type of action (RIA or IA)	IA		
Programme Area	SYS – WP5.2.1		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	1000 k€	Type of agreement	Implementation Agreement
Duration of the action (in Months)	30 months	Indicative Start Date[56]	Q2 2017

Identification	Title
JTI-CS2-2016-CFP04-SYS-02-23	ECO-design based techniques and machinery for improved racking and distribution boxes
Short description (3 lines)	
The main target of the call is to develop breakthrough & hybrid additive manufacturing/3D printing ECO-conception techniques and to incorporate them into industrial process. At the end of the project a Hybrid Machine will be delivered. This machine will be able to ensure additive manufacturing demonstration. Intermediate demonstration is also targeted with high temperature plastic & metal printing.	

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

1. Background

The activity of WP 5.2.1 Innovative Electrical Network is part of WP 5 Elecrical Chain.
The obejctive will be to specify, design and develop additivie manufacturing toolmachnery based on the use of electrical conductive and non-conducitive materials appplied to innovative electrical distribtution boxes.
The electrial boxes thus obtained will be equiped with electrical network that will be inherent and imerged to the structure of the electrical box itself.

All components & materials that will be developed in the frame of this project:
- Must be REACH compliant.
- Must be optimised in term of weight, volume and cost.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T1	**Machinery Specifications** The main objective of this task is to adapt conventional electrical cabinet manufacturing process specifications to Hybrid additive manufacturing process specifications. Including: - General tolerance - HSE - Equipment requirements - Monitoring of means - Qualifications - Operating conditions → this activity will be closed by a review: Process Specification review	T0+2
T2	**Materials Specifications** The objective of this task is to provide minimum requirements of conducting and non-conduction materials to be used. Including: - General mechanical, electrical and thermal requirements - Use conditions - Inspection → This activity will be closed by a review: Materials specification review	T0+4
T3	**Sample Definitions** The objective of this activity is to define sample geometries and associated qualification test plan (QTP) →This activity will be closed by a review: QTP review	T0+6

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T4	**Process versus materials choice** The main objective of this task is to provide a comparative study of appropriate additive manufacturing processes versus materials to be used related to T1 and T2 specifications. The comparative study shall include an evaluation rating providing recommendations for decision-making. →This activity will be closed by a review: Process/Materials selection Review	T0+8
T5	**Machinery design** The main objective of this task is to check if the preliminary machinery design is consistent with requirements and specifications related to T1 and T2, prior to launch machinery prototype manufacturing. Full CAD definitions shall be provided. → This activity will be closed by a review: First Design Review (DR1)	T0+13
T6	**Prototype Manufacturing** The main objective of this activity consists of manufacturing the Machinery prototype in order to provide validation samples tests. → This activity will be closed by a Machinery and Sample review and by samples delivery	T0+19
T7	**Samples tests** This activity consist of performing the QTP on Samples fabrication and verification of their conformity to specifications related to T1, T2 and T3 →This activity wil be closed by QTR (qualification test report) validation and a FSQ (File synthesis of Qualification)	T0+22
T8	**Loop on design, needed in case of T7 failure** The objective of the activity is to modify Machinery in order reach requirements related to T1, T2 and T3. →T5, T6 and T7 shall be updated in order to closed this activity	T0+28
T9	**Final machinery delivery**	T0+30

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***
D1.T1	Hybrid additive manufacturing machinery specifications definition related to the Topic leader electrical box use-case.	Document	T0+2
D1.T2	Specification of conducting and non-conduction materials to be used.	Document	T0+4
D1.T3	Sample definition and associated QTP	Document	T0+6
D1.T4	Comparative study of appropriate additive manufacturing processes versus materials to be used.	Document	T0+8
D1.T5	Initial Machinery designs according to the options of the chosen materials	Document	T0+13
D1.T6	Machinery mock-up fabrication	Document	T0+19
D1.T7	Samples fabrication and verification of their conformity to specifications	Samples and document	T0+22
D1.T8	Adaptation of the machinery (if needed)	Document	T0+28
D2.T8	Machinery fabrication update	Document	T0+28
D3.T8	Samples fabrication and verification of their conformity to specifications	Samples and document	T0+28
D1.T9	Final machinery delivery	Machinery	T0+30

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M0	Kick off Meeting	Review	T0+1
M1.T1	Process Specification review	Review + Delivery	T0+2
M1.T2	Materials specification review	Review + Delivery	T0+4
M1.T3	QTP review	Review + Delivery	T0+6
M1.T4	Process/Materials selection Review	Review + Delivery	T0+8
M1.T5	First Design Review (DR1)	Review + Delivery	T0+13
M1.T6	Machinery and Sample review and Samples delivery	Review + Delivery	T0+19
M1.T7	QTR validation and a FSQ delivery	Review + Delivery	T0+22
M1.T8	Second Design Review (DR2) if needed (See M1.T5)	Review + Delivery	T0+28

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M2.T8	Machinery and Sample review and Samples delivery Update (See M1.T6)	Review + Delivery	T0+28
M3.T8	QTR validation and a FSQ update delivery (See M1.T7)	Review + Delivery	T0+28
M3.T9	Final machinery delivery	Review + Delivery	T0+30

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

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

- Skill 1: Capacity of Additive Manufacturing for aeronautic use
- Skill 2: Capacity to use a range of different materials: metals, ceramics, polymers, composite materials
- Skill 3: Capacity of excellent reproduction of the defined samples specification
- Skill 4: Proved capacites and expertise in elecrical engeineering
- Skill 5: Capacity of producing machines that produce functional, end-use aerospace and defense parts.
- Skill 6 Capacity to use hybrid materials and to build capabilities in order to reduce aerospace part weight while improving overall efficiency in meaningful and measureable ways
- Skill 7: Aeronautic knowledge and experience
- Skill 8: 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

IV. Electrical simulation model identification method and tool

Type of action (RIA or IA)	IA		
Programme Area	SYS – WP5 [Electrical Chain]		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	350 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	36 months	**Indicative Start Date**[57]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-SYS-02-24	**Electrical simulation model identification method and tool**
Short description (3 lines)	
Development of model updating methods for complex electrical simulation models. This will include methods for accurate model parameters identification, methods for parametric optimization of model updating process based on experimental data and assessement methods for model validation.	

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

1. Background

The System ITD of Clean Sky 2 aims to contribute to aircraft weight and environmental footprint reduction. Among the systems, equipments and functions contributing to these environmental objectives, the more electrical aircraft technologies are key elements. The maturity of these technologies will be assessed in System ITD in local test benches and integrated demonstrators.
For electrical systems, comprehensive validation and verification activities are mandatory to demonstrate substantial performance. Indeed, by correlating performances and design margins of both network and equipment, aircraft manufacturers ensure safe and reliable operation: any sub-system not complying with its specification requirements may lead the network exceeding its operating limits, further leading to improper operation and additional failure. Moreover, the mastery of design margins is a key lever to improve performances and optimize weight at system and aircraft level.

In Clean Sky 2 System ITD, WP5.0 focuses on Aircraft Electrical Architecture. Definition and validation of the electrical network, including core electrical equipments, will be done in a complementary way by simulation studies and demonstration of equipment and network operation on a test rig. An adequate simulation platform, including accurate and robust model library and advanced post processing tools, is required to reach simulation V&V goals.
In previous aircraft programs and research project, SABER simulation software has demonstrated its suitability to fully support aircraft electrical network V&V process. SABER RD robust generic electrical model libraries have been developped to be used as a baseline for specific model development. However, experience from these previous projects shows that the availability of accurate models can be late in the project, taking a slice out of the full simulation contribution potential for V&V activities.
Hence, the aim of this project will be to provide the capacity to adapt generic models to fit real hardware from experimental measures and/or design data. Model fitting methods selection and development will have to be performed for each phase of equipment development, that is to say from design to hardware validation.

2. Scope of work

The Clean Sky 2 System ITD is looking for specialists in SABER RD modelling and electrical engineering to become partner of the consortium taking part in virtual platform consolidation by performing the following tasks:

- To develop or adapt existing identification and fitting methods to fit electrical models
- To adapt or create SABER RD electric generic models to be used to fit hardware
- To develop tools to be used in SABER RD to fit generic models from experimental data

The target is to adress all main components of an aircraft electrical network, from electrical power source, through electrical converters to electrical loads. Hence, the scope of hardware to be fitted is:

- Electrical power sources:
    - AC generator - 3 stages variable frequency starter generator, Permanent magnet generator

- DC generator – AC generator associated with an AC/DC converter, DC battery

- Power converters:
    - AC/AC converters – Transformers, Auto Transformers
    - AC/DC converter – Rectifier, DC/AC, DC/DC and
    - DC/AC converters - Inverters
    - DC/DC converters – Buck/Boost converter, …
- Power loads
    - Electrical machines – Synchronous machine, asynchronous machines

A special attention shall be be paid on filters of these equipments, having a major contribution on electrical network power quality and stability.

Task 1: Identification and fitting methods

In this task, a first activity will be to perform bibliographical research on identification and fitting methods for electrical equipments, that is to say:

- Identification methods: for each type of electrical hardware (according to equipment list provided in task 1), key parameter definition and parameter identification methods (test procedures and post processing from measures) shall be provided and compared leading to identification of the best methods.
- Fitting methods: to provide methods and algorithms (for example optimisation algorithm) adapting model parameters to fit with hardware behaviour.

A second loop, dedicated to identification & fitting method choice and adaptation, is required to adapt state of the art methods to this specific application.

Validation of these methods will be performed either through performing dedicated measurements on a test rig or using existing experimental data. The demonstration will be performed using task 2 models and scripts developped in task 3 and according to an accuracy criterion for comparison between simulation results and measures.

Task 2: Adaptation or creation of generic models

A dedicated electrical generic model library has been developped in previous project to be used to simulate aircraft electrical network, paying a specific attention to the robustness of the model to ensure convergence at network level. According to the outcome of Task 1, an adaptation of such a library may be required, enabling the tuning of specific parameters for each type of electrical hardware.

Task 3: Development and validation of a Toolbox dedicated to electrical model fitting

Task 3 is dedicated to script development allowing to identify key parameters from measurements and to tune adapted electrical models according to identification and fitting methods.

Identification scripts will dedicated to:

- Model parameter identification through measurement post processing
- Model fitting through specific algorithms and according to experimental data

Ergonomy of this toolbox shall be a key driver.

Finally, a high level script shall allow to manage parameter identification, model fitting and fitted model generation. A graphical user interface under Saber RD shall fulfill this requirement by linking data provided by test rigs and simulation. This task is applicable for all topologies and all type of electrical models, consumers or generators.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
1	Identification and fitting methods applicable to fit electrical models	T0+24
2	Adaptation or creation of electrical generic models to be used for fitting hardware	T0+30
3	Toolbox to perform parameter identification and to fit electrical models according to experimental data	T0+36

3. Major deliverables and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1.1	Preliminary Identification & fitting methods applicable to electrical models	Doc	T0+6
D2.1	Preliminary Update of generic electrical SABER model library	Model Library	T0+12
D3.1	Preliminary Toolbox to fit electrical models according to experimental data	Tool	T0+18
D1.2	Refined Identification methods applicable to fit electrical models	Doc	T0+24
D2.2	Refined Update of generic electrical SABER model library	Model library	T0+30
D3.2	Refined Tools to fit electrical models according to experimental data	Tool	T0+36

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Preliminary version of identification & fitting methods, model library & Fitting Toolbox – validation according to experimental data	Review	T0+18

4. Special skills, Capabilities, Certification expected from the Applicant

- Strong expertise in script and graphical user interface development in SABER RD environment
- Strong expertise in Modelling development and fitting process in SABER RD environment
- Strong expertise in electrical enginnering & parametric identification and fitting methodolgies

V. Innovative cooling system for embedded power electronics

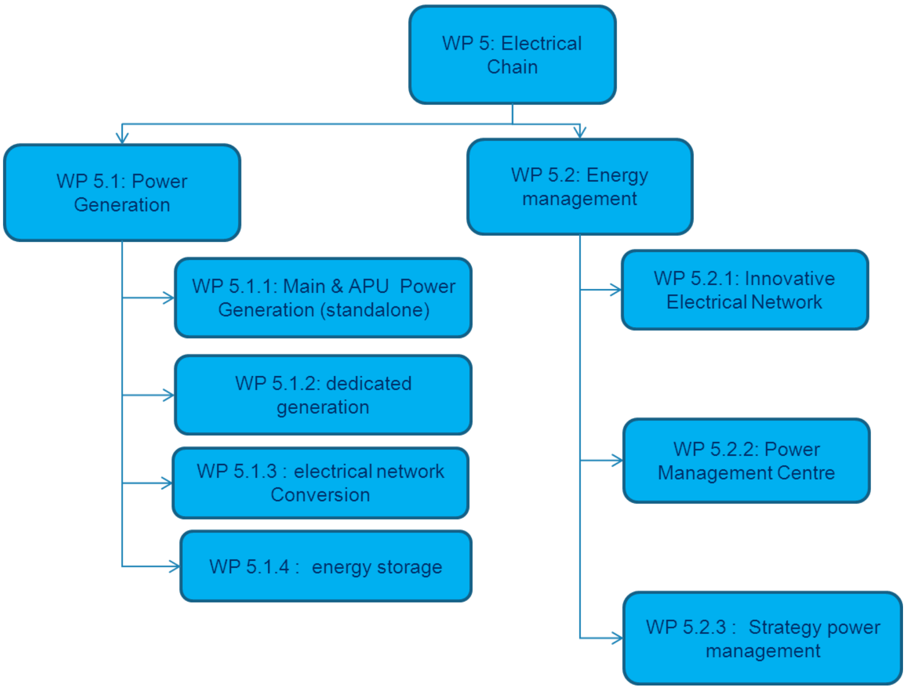
Type of action (RIA or IA)	IA		
Programme Area	SYS – WP 5.2.2.2		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	800 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	28 months	**Indicative Start Date**[58]	Q2 2017

Identification	Title
JTI-CS2-2016-CFP04-SYS-02-25	**Innovative cooling system for embedded power electronics**
Short description (3 lines)	
The next generation of power electronic module needs to be highly integrated to reduce the weight impact for the more electrical aircraft. If new technologies of power components such as SiC and GAN support higher temperature environment, these power components need to be cooled to maintain reliable operating temperatures. The challenge is to develop effective heat sinks that serve for extracting and transferring the dissipated power from the power semiconductors with removal of heat by means of air flow through the heat sink. For this application, the partner shall combine material with high thermal conductivity properties and optimized folded brazed fin heat sink solution. The evaluation of heat sink prototypes is expected as a stand-alone effort and also in a mechanical structure to represent a power management system integrating a few electronic modules equipped with the high efficiency heat sink technology.	

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

1. Background

The WP5 WBS and objectives of the WP5.2 in which the CfP is proposed.



The major objective of "Electrical network conversion" project is to actively prepare the ATA24 System for the future generation of aircraft power network and to develop the next generation of power electronic equipment. Through these studies, process and technologies will be evaluated and challenged to usual solutions.

Future Aircraft need more electrical power on board in less space. Thermal performance may become an issue with the advent of ever higher power densities through the use of new semiconductor technologies supporting higher temperature environment. This challenge shall be met by establishing new control laws to reduce switching losses and pursuing advanced designs with new materials supporting higher temperature gradients. Today the state-of-the-art thermal management system is estimated to have a specific mass of about 5 kg/kW for passive solutions (hydraulic cold plate) as well as active technology such as dual phase one. With regard to reliability and maintenance aspects, a passive solution may be preferable. The main technical target for this topic is developing advanced heat sinks using innovative technology ensuring high thermal conductivity and uniform spreading of the heat across the surface of the heat sink aiming at reaching a mass/power ratio towards 2 or 3 kg/kW. This technology shall be evaluated regarding the feasibility of meeting the requirements and constraints of aircraft applications.

2. Scope of work

For this application, the partner shall develop advanced heat sinks using innovative Annealed Pyrolytic Graphite (APG) technology ensuring very high thermal conductivity and uniform spreading of heat across the surface of heat sink in addition to implement advanced and optimized folded brazed fin heat sink solution. This solution may be complemented at a later stage by a highly advanced Metal Matrix Composite (MMC) technology used for primary heat transfer surfaces of a heat sink. This MMC technology is highly innovative and holds remarkable potential for next generation heat dissipation devices. Therefore, development of highly advanced heat sinks for a more electric aircraft application shall be proposed in two stages – (a) heat sink using APG and aluminium optimized folded brazed fin technology as a first step; and (b) heat sink using APG and MMC technologies as a second step to evaluate this promising research. For this topic, evaluation of heat sink prototypes is expected as a stand-alone effort but also will be conducted within a mechanical structure to represent a power management system integrating four (4) power electronics modules equipped with the innovative heat sink technology and cooled by air flow.

The list of tasks are identified below in the table:

Tasks		
Ref. No.	***Title – Description***	***Due Date***
Task 1	Establish state of the art of heat sink and of the material with high thermal conductivity and by taking account the mechanical forms of the heat sink (specific shapes and fixing hole) to estimate the degradation of thermal performances and to define design rules of heat sink.	T0 + 1 Month
Task 2	Thermal analysis, by modelling the thermal behavior for the chosen technology of heat sink and for the power management system integrating four (4) dissipated power modules.	T0+ 2 Months
Task 3	Design the innovative heat sink (stage a) with APG technology and optimized folded brazed fin technology and 3D (three dimensions) model with CATIA tool. Study the thermal performances by optimizing the component location on the heat sink.	T0 + 6 Month
Task 4	Manufacture and delivery the innovative heat sink mock-up , first run with five (5) heat sinks for evaluation test including two (2) prototypes for the topic manager company for evaluation of the integration of the power component	*T0 +12 Months*

Tasks		
Ref. No.	***Title – Description***	***Due Date***
Task 5	characterize performances and robustness - thermal - mechanical - robustness note: evaluate robustness to an environmental representative stress. Robustness tests are destructive ones allowing a definition of a margin design (upper limit and lower limit of destruction) and a drift of a key parameters.	*T0 +16 Months*
Task 6	Design a second run to optimize the heat sink (stage b) combining APG, MMC and folded brazed fin technologies and 3D (three dimensions) model with CATIA tool. Study the thermal performances by optimizing the component location on the heat sink.	*T0 +18 Months*
Task 7	Manufacture and delivery the second run of prototype (quantity = 5 including 2 heat sinks for the topic manager)	*T0 +24 Months*
Task 8	Perform the characterization of the second run as defined in task 5	*T0 +28 Months*
Task 9	Test bench development to reproduce the power module environment (weight, size, thermal profile) and to test the two runs of heat sink prototypes	*T0 +10 Months*
Task 10	Design a mechanical structure to develop the power management system which will be equipped with 4 power modules with air flow cooling and 3D (three dimensions) model with CATIA tool	*T0 +12 Months*
Task 11	Manufacture two (2) mechanical structures equipped with four (4) dedicated heat sinks and delivery one mechanical structures for the topic manager after the manufacturing and the second will be delivered to the topic manager after the task 12 performed	*T0 +18 Months*
Task 12	Perform tests and reports. Topic manager will help in tests procedure elaboration. Tests will be done by supplier. In case of lack of test benches, supplier shall find adequate suppliers.	*T0 +24 Months*

The goal of this topic consists on proposing to progress the following activities:

- Establishing state of the art heat dissipation materials with high thermal conductivity, material performances are gathered but also the manufacturing process to analyze the facility of access and costs efficiency.
- Design efficient thermal heat sink to meet the requested heat performances. The design needs to meet also the aircraft environment requirements including vibrations; shocks, humidity, fluids susceptibility, salt spray, (standard shall be specified, but as reference compatible with the DO standard).

- Manufacture prototypes of the heat sink with two combined technologies, first stage (a) with APG and folded brazed fin solution and second stage (b) with APG, MMC and folded brazed fin technologies. The manufacturing processes and the material used for the heat sink shall be compliance with REACH (Registration, Evaluation, Authorization and restriction of Chemicals) and ROHS (Restriction of the use of Hazardous Substance) directives.
- Characterize the thermal performances, and also the compliance with the environment requirements (mechanical and robustness aspects), analysis shall do by testing following standard procedures.
- Manufacture two (2) mechanical structures integrating 4 heat sinks to evaluate a thermal management system by using air flow cooling solution.

Notes:

- Parametric analysis are expected on the three main parameters concerning the air inlet temperature, the air flow and the temperature reachable on the heat sink, the heat sink position on the heat sink and the heat sink position in the bay shall be defined after analyzing the results of the parametric analysis.
- To characterize the performances of the heat sink, the partner will use active load to create the profile of heat source generated by the power components.
- To reproduce the air flow conditions, the partner is responsible of the integration and shall provide the means to generate the airflow usefully to evaluate the heat sink and the bay.

Application description, key figures with some information will be confirmed for the first part of this project, but the main values are presented hereafter:

Power electronic equipment cooled by the expected innovative heat sink :

- Thermal performances:
  - Dissipated power by the heat sink :
    - Permanent mode : 800W
    - Transient mode: 1300W (profile of the transient mode shall be defined in the first part of the project).
  - The power density in surface of power component shall reach the 100W/cm² and the surface area of the dissipated power is 160cm² (large 80 mm by Long 200mm)
  - The dimensions of the heat sink are 250mm large, 300mm long and 15mm high. The heat sink dimensions and the location on the heat sink will be defined to achieve the thermal performances.
  - Range of the maximum inlet temperature +55°C to +65°C
  - Minimum inlet temperature : -55°C
  - Range of the minimum air flow on the heat sink: 20g/s to 40g/s, parametric analysis should be expected to identify the optimized solution; parallel or serial connection should be evaluated and for this range of value, power extracted by the heat sink and the temperature on the heat sink need to be calculated for comparison with the expected level of requirements.
  - Temperature on surface of the heat sink: around 115°C +/-5°C.

- Mechanical performances:

- vibration spectrum conform to the D0160 standard
- choc applicate conform to the D0160 standard
- mechanical interfaces:
  - with the other power components fixed on the heat sink:
    - solution with insert need to be proposed
  - with the structure :
    - solution developed need to allow easy maintenance and extractible
    - contact resistance between the heat sink and the mechanical structure : very low and milli-ohm need to be reachable
    - noise level : compliance with aircraft standard

For this topic, a thermal analysis of a thermal management system integrating four (4) heat sinks is also requested. This analysis shall defined the thermal architecture usefully to extract the calories of these four heat sinks integrated in a closed mechanical structure called a bay; This bay will be cooled by air flow and the study shall also define the connections of the heat sinks to extract the calories concerning the following requests:

- the four heat sinks could be solicited through the same thermal profile defined in the previous paragraph
- the mechanical structure shall be developed to integrate also other equipment, specific dimensions and definition shall be given by the Topic manager at the beginning of the task 10.
- air flow on the inlet of the bay
  - range of the maximum air temperature : +55°C to +65°C
  - minimum air temperature : -55°C
  - air flow on the inlet of the bay : 100g/s

3. Major deliverables / Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Report state of the art with design rules and optimizations solution for the heat sink and the mechanical structure	document	T0 + 2 Month
D2	Thermal performances description taking account the component location with the definition file of the heat sink RUN1 (stage a) and 3D (Three dimensions) model with CATIA tool.	Documents &3D model	T0 + 6 Month
D3	Delivery of five (5) prototypes RUN1	Hardware	T0 + 12 Months
D4	Thermal model of the heat sink and thermal model of the mechanical structure (compatible to ANSYS tool)	model	T0 + 12 Months

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D5	Report on performances and robustness RUN1	document	T0 + 16 Months
D6	Thermal performances description taking account the component location with the definition file of the heat sink RUN2 (stage b) and 3D (Three dimensions) model with CATIA tool	Documents & 3D model	T0 + 18 Month
D7	Delivery of five (5) prototypes RUN2	Hardware	T0 + 24 Months
D8	Thermal model of the RUN2 heat sink (compatible to ANSYS tool)	model	T0 + 24 Months
D9	Report on performances and robustness RUN2 and updated thermal model	Document & model	T0 + 28 Months
D10	Definition file of test bench	document	T0 + 10 Months
D11	Definition file of the mechanical structure and 3D (Three dimension) model with CATIA tool	Document & 3D model	T0 + 12 Months
D12	Delivery of one (1) mechanical structure	Hardware	T0 + 18 Months
D13	Thermal model of the mechanical structure	model	T0 + 18 Months
D14	Report on performances of the mechanical structure equipped with heat sinks and updated thermal model	Document & model	T0 + 24 Months
D15	Delivery of the second mechanical structure to the Topic manager	Hardware	T0 + 25 Months

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
Trade Review	state of the art and thermal analysis	Document	T0+2M
Design review 1 RUN 1	Preliminary design review of the heat sink RUN 1 (stage a)	Document	T0+5M
Design review 2 RUN 1	Conception design review of the heat sink RUN 1	Document	T0+8M
Article review RUN1	deliver prototypes RUN 1 according to the definition	Hardware	T0+12M

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
Test review RUN1	Evaluate electrical, mechanical and robustness performances according to evaluation procedures specification jointly by the applicant and Topic Managers company	Document	T0+16M
Design review RUN 2	Conception design review of the heat sink RUN 2 (stage b)	Document	T0+18M
Article review RUN 2	deliver prototypes RUN 2 according to the definition	Hardware	T0+24M
Test review RUN 2	Evaluate electrical, mechanical and robustness performances according to evaluation procedures specification jointly by the applicant and Topic Managers company	Document	T0+28M
Design review Test bench	Conception design review of the test bench	Document	T0+10M
Design review mechanical structure	Conception design review of the mechanical structure	Document	T0+12M
Integration review	Integration of the mechanical structure	Hardware	T0+18M
Test review mechanical structure	Evaluate electrical, mechanical and robustness performances of the mechanical structure equipped with the updated heat sinks according to evaluation procedures specification jointly by the applicant and Topic Managers company	Document	T0+24M

4. <u>Special skills, Capabilities, Certification expected from the Applicant</u>

The applicant will be able to:

- Develop cooling system using air flow for aircraft application
- Define test plan following aircraft standard (D0160),
- Design heat sink and mechanical structure, and using CATIA tool or equivalent tool,
- Manufacture or master the manufacturing process for mechanical pieces and for the brazing of fins,
- Be compliant with REACH and ROHS directives,
- Ensure timely management of study and development phases; available resources to execute the respective tasks should be stated in the proposal,
- Model thermal behavior of heat sinks and also thermal management systems with ANSYS software

tools,

- Characterize heat sink and cooling system and conduct fatigue and combined robustness tests.
- Manufacture process, test benches with air flow means to develop and test requested in respect with milestone of delivery,

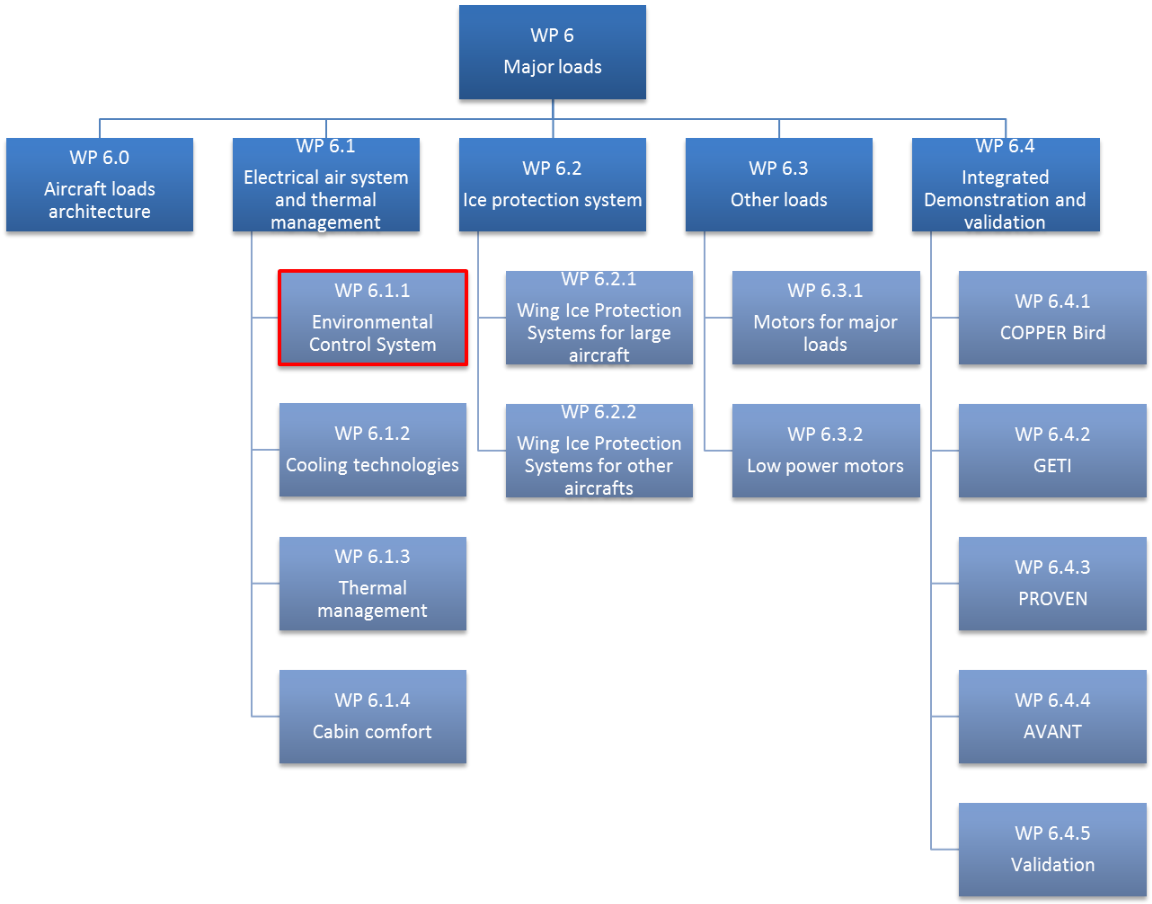
VI. Multivariable control approach for electrical air conditioning pack

Type of action (RIA or IA)	IA		
Programme Area	SYS – WP6 Major Loads		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	500 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	36 months	**Indicative Start Date**[59]	Q2 2017

Identification	Title
JTI-CS2-2016-CFP04-SYS-02-26	**Multivariable control approach for electrical air conditioning pack**
Short description (3 lines)	
In order to support an optimized EECS, this topic aims to develop and to test on test rig a multivariable control approach for electrical air conditioning pack, in order to improve transient thermodynamic performance and passenger comfort and to reduce (electrical) power consumption	

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

1. Background



The objective of the WP6.1.1 Environmental Control System is to investigate Electrical ECS for more electrical aircraft. The studies will be focused on the refinement of EECS architectures (including thermal management perimeter) for a single-aisle application based on experience gained on Clean Sky 1 . The studied perimeter will be extended for trans-ATA consideration and a full scale e EECS demonstrator for Large aircraft application will be developed and validated up to TRL6 in the frame of a flight test campaign.

The electrical air conditioning pack consists of a motorized air cycle machine with variable nozzle area, heat exchangers, electrical fans, jet pumps, valves and ram air doors. The flow and the temperature at pack outlet are controlled based on cabin and cockpit requirements. The electrical power consumption shall be minimized.

The electrical air conditioning pack has a nonlinear behaviour.

The electrical air conditioning pack uses several high level control modes (typically 16 control modes for Epack single aisle demonstrator), which are more complex than current pneumatic pack controls: there are several control modes depending on aircraft altitude, outside ambient temperature, cooling or heating demand. Those control modes are designed to optimize electrical consumption throughout the whole flight envelope, and also to avoid surge of compressors.

Each of these modes is currently carried out by mono-variable control, with a lot of complexity and low transient performance for some configurations, in order to keep reduced electrical consumption overshoots. This complexity leads to long development and test durations for control activities. And the low transient response shall be improved in order to improve passenger and crew members comfort.

Furthermore the validation and the calibration of the dynamic physical model currently requires a lot of test and calculations, as well as the calibration of the control laws on the test rig.

The topic will focus on thermodynamic modelling and multivariable control of an electric air conditioning pack. Electrical power consumption which is a performance objective for the control will be addressed considering instantaneous power at system level. In a multi-physic approach, interfaces with electrical models and controls could be prepared.

The first objective of this topic is to develop a multivariable control approach for electrical air conditioning pack, covering all or most of the control modes, in order to reduce complexity and to improve the transient performance.

The second objective is to get a description of a model and a control laws calibration method, with some associated tools, in order to provide better calibration results and lower calibration time.

The topic manager gets Simulink physical model of an electrical air conditioning pack, as well as a test rig and some test data of this pack. Some test can be carried out by the topic manager on partner(s) request at the Topic Manager's facilities. The control and tuning method proposed by the partner(s) will be tested on the topic manager test rig in his own facilities.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 1	Definition of the requirements	M2
Task 2	Definition of an efficient calibration method for dynamic physical model (based on test results)	M12
Task 3	Development of electrical pack multi variable control Assessment of dynamic performance and robustness of developed control Tests on Topic Manager's facilities and validation of the obtained results	M36

Task 1 : Definition of requirements and gathering of information to be provided to the partner :

At the beginning of the project, the topic manager will define the following requirements in D01.1:

- Detail the available or requestable test data that will be the inputs of tasks 2.

- Detail the performance control requirements for task 3 and the challenges already encountered on electrical air conditioning pack activites already carried out by the topic manager.

The topic manager will share with the applicant the following informations:

- Pack Control modes (with electrical consumption optimization targets), transient requirements,
- Current Simulink model (initial and calibrated physical model, control model) of the electrical pack
- Equipment Test data and system test data recorded on the pack test rig
- Requirements for control embodiment in aeronautical controller (compatible with SCADE and HILR requirements)

Task 2 : Definition of an efficient calibration method for dynamic physical model:

A calibration method shall be defined for the dynamic physical model of an electrical air conditioning pack, including:

- A list of components and system test cases to be performed, with associated data to be recorded
- A detailed description of the parameters to be calibrated and the way to calibrate them based on the test results
- A tool providing automatic test post treatment and calibration of the physical model parameters values. That tool shall not be specific to the pack studied in this call for partner, it shall be applicable to other electrical air conditionning packs having a rather similar architecture but components of a different size.

Task 3 : Development of electrical pack multi variable control :

The partner(s) shall present the multi variable strategy and theory that it has already developed and the method used to do it.

The partner(s) shall propose and describe a method to define a multi variable control covering most of the electrical air conditionning pack control modes in order to meet the control requirements provided in D01.1. This method shall be applicable to any electrical air conditionning pack, in order to re-use it on future electrical packs. This method shall be compliant with industrial development time: reduced number of test cases, able to be used for aeronautical application. The multi variable control shall be compatible with the Topic Manager certification standards and processes (e.g. based on SCADE tool chain), in order to be embeded in a certifiable aeronautical controller. The partner(s) shall provide tools used to define, apply and calibrate the multi variable control design. These tools shall be applicable to other electrical air conditionning packs having a rather similar architecture.

Then it shall provide a model of those control laws and show that the model meets the control requirements provided in D01.1. In particular, the partner(s) shall assess the dynamic performance and the robustness properties of the developed control.

Those control laws will then be tested on the topic manager test rig. The performance obtained during these tests will be validated and correlated with the assessed performance for the control by the partner(s).

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables				
Ref. No.	***Title - Description***	***Provided by***	***Type****	***Due Date***
D01.1	Detailed control requirements, topic manager's Simulink models, test data	Topic Manager	R + model + D	M2
D02.1	Dynamic physical model calibration method, including list of additional tests requested	Partner(s)	R	M8
D02.2	Additional tests data requested in D02.1	Topic Manager	D	M10
D02.3	Dynamic physical model calibration method and results, including associated tools and calibrated model	Partner(s)	R + tool + model	M12
D03.1	Intermediate report : description of the way to define multi variable control laws for electrical air conditioning pack	Partner(s)	R	M8
D03.2	Identification or definition of electrical air conditioning pack multi variable model(s) for control (linear process model(s) for control : multivariable transfer function(s), state space model(s),…)	Partner(s)	R + D	M14
D03.3	Detailed description of the way to define multi variable control laws for electrical air conditioning pack : theoretical description, retained strategy to meet D01.1 control requirements, expected performance for the Multivariable Control (dynamic performance + robustness assessment)	Partner(s)	R	M20
D03.4	First release of Toolbox for identification and multi variable control design	Partner(s)	Tool	M24
D03.5	Multi variable Control laws and model linked to the physical model	Partner(s)	Model	M26
D03.6	Dynamic performance and robustness assessment for the developed control vs expected performance in D03.3	Partner(s)	R	M26
D03.7	Test data recorded during test of the control laws D03.5 on the pack test rig	Topic Manager	D	M30
D03.8	Validation by the partner(s) of the obtained performance on the pack test rig vs expected performance in D03.3	Partner(s)	R	M30
D03.9	Final release of Toolbox for identification and multi variable control design	Partner(s)	Tool	M36

Milestones			
Ref. No.	***Title - Description***	***Type****	***Due Date***

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

4. Special skills, Capabilities, Certification expected from the Applicant

Applicant shall show a strong experience in the following fields:

- Automatic and control, especially multi variable control and innovative control solutions
- Dynamic modelling and model calibration of nonlinear physical systems including valves, heat exchangers, air cycle machines, actuators, electrical motors, pressure, flow and temperature sensors
- Thermodynamics and fluid mechanics of heat exchangers, air cycle machine, ducts

5. Abbreviations

HILR	Hardware In the Loop Rig
SCADE	Embedded software design software

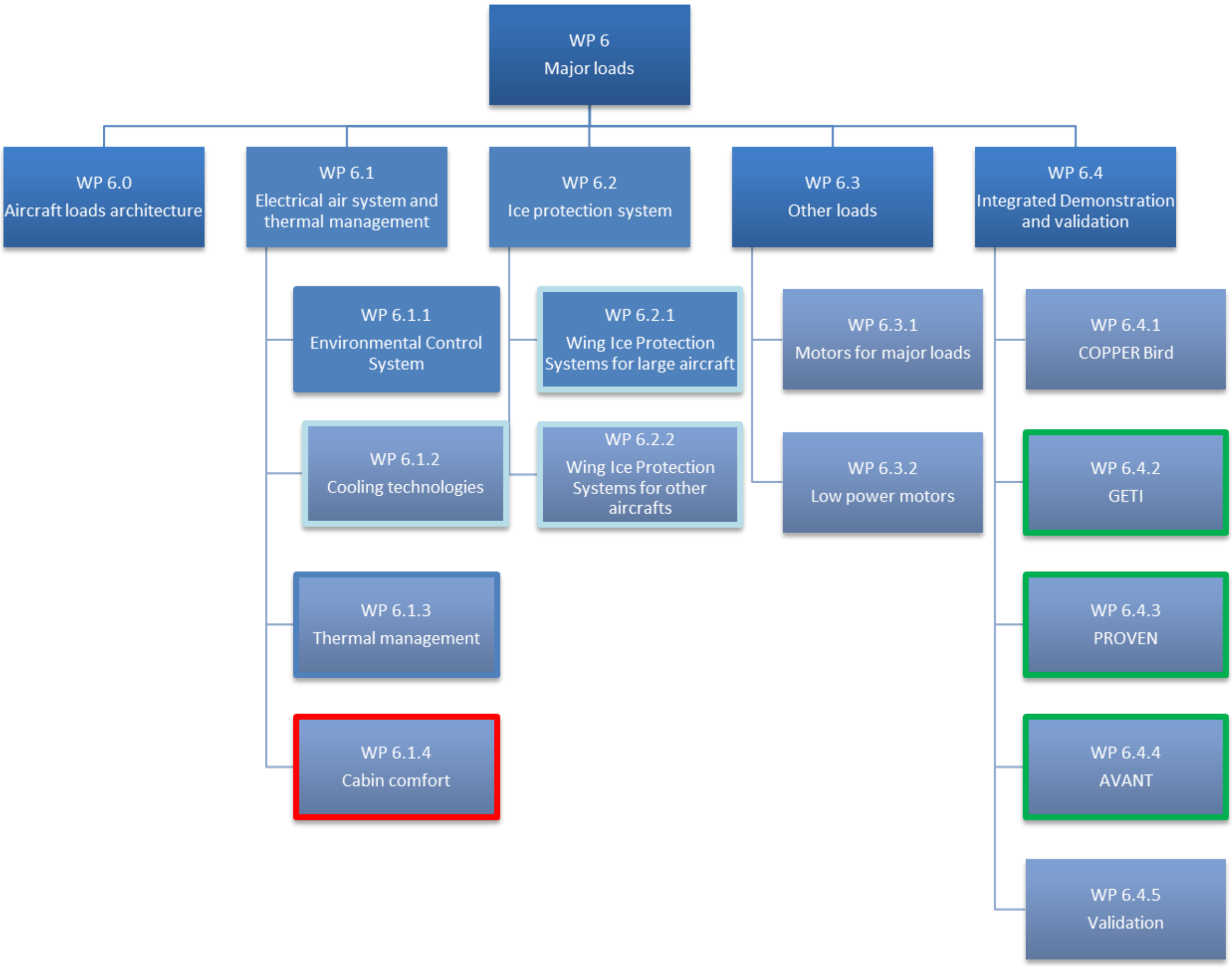
VII. Alternative recirculation filter for better cabin air quality

Type of action (RIA or IA)	IA		
Programme Area	SYS – WP6		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	1100 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	36 months	**Indicative Start Date**[60]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-SYS-02-27	**Alternative recirculation filter for better cabin air quality**
Short description (3 lines)	
The objective of this study is to provide an alternative purification solution to improve the efficiency of air filter dedicated to the elimination of VOCs (excluding CO2) and bio-contaminants, excluding all solutions generating ozone, in cabins and in aircrafts. In addition the proposed solution shall integrate a particular filter.	

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

1. Background



The objective of the WP6.1.4 is to investigate solutions to improve air quality and cabin comfort for more electrical aircraft. The studies will include the development of devices enabling to remove VOCs generated in the cabin (foods, material in the cabin) and entering in the cabin through the air conditioning system. The removal of ozone at low temperature (specific request due to bleedless E-ECS) will also be adressed. Such air quality systems will be associated to monitoring functions in order to control the air quality in the cabin.

The objective of this study is to provide an alternative purification solution to improve the efficiency of air filter dedicated to the elimination of VOCs (excluding CO2) and bio-contaminants, excluding all solutions generating ozone, in cabins and in aircrafts. The generation of ozone will constitute a basis for a risk evaluation for crew members and passengers. In addition, the proposed solution shall integrate a particular filter in order to avoid a pressure drop in air system lines which can lead to higher energy consumption. The solution expected should be innovative and alternative to current absorption filter. It should not involve CO2 treatment and monitoring.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T01	Specification of VOCs: - Pollutants to be eliminated : acrolein, toluene, acetaldehyde with at least 85% efficiency without generation of by-products - Environmental constrains : relative humidity, variation of pressure in an aircraft - Integration constrains (see T06 below)	2017
T02	State of the art: - Literature and patents review - Screening of air filter technologies - Review of aerospace standards for cabin air quality	2017
T03	Development of filter - Development of air filter according the specifications - Experimental tests with an accurate injection and measurement of pollutants - Evaluation of biocide effect closed to bacteria and viruses	2018
T04	Experimental validation - performance tests: Conversion of pollutants (VOC) into CO_2 - Validation of selectivity measurements of products - Carbon mass balance upstream and downstream of filter - Biocide effect of air filter	2019
T05	Ageing tests validation - Ageing media behavior - The effect of humidity, pressure on odor elimination - Estimation of an average real life of air filter – min: 3000 FH (regeneration or replacement of filter)	2019

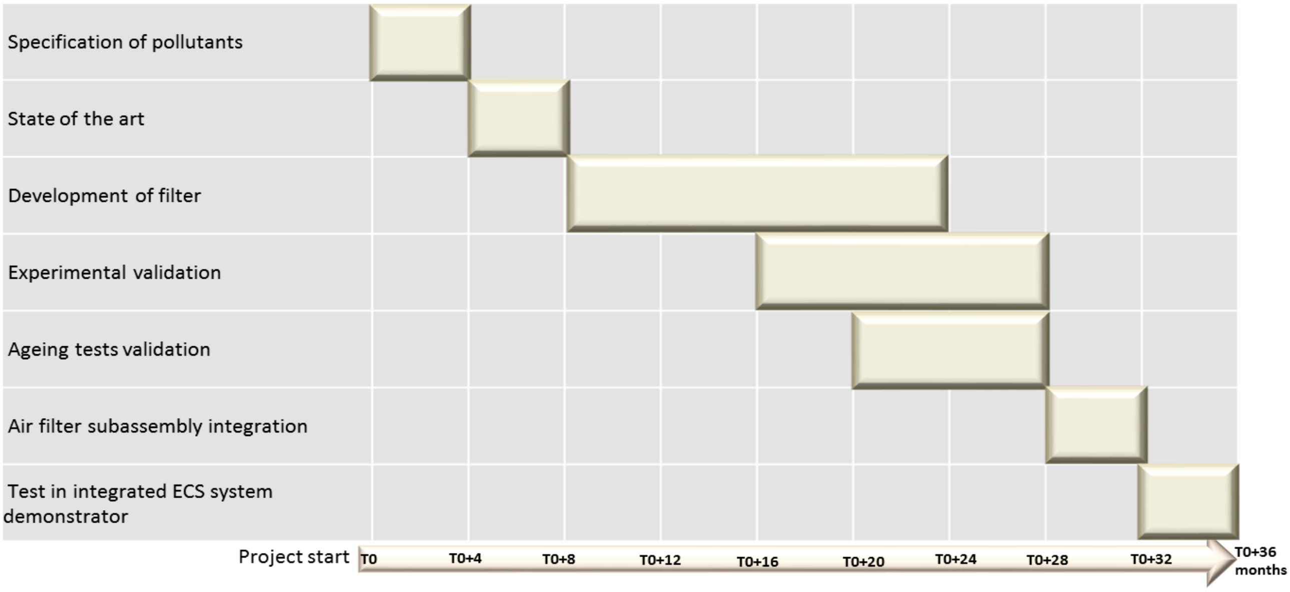
Tasks		
Ref. No.	***Title - Description***	***Due Date***

T06	Air filter subassembly integration:
	The equipment integration into aircraft considering the here below features :
	- Air flow : 420l/s from sea level to 8000ft
	  ○ Weight 9kg clean
	  ○ Air pressure drop 6 mbar clean and 10mbar end of life
	  ○ max length 550 mm , max width 500 mm
	- Air flow : 300 l/s from sea level to 6000ft
	  ○ Weight 9 kg clean
	  ○ Air pressure drop 6 mbar clean and 10 mbar end of life
	  ○ max length 550 mm , max width 500 mm
		2020

T07	Test in integrated ECS system demonstrator in topic manager's facilities	2020

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D.01	Bibliography report	R	2017-2018
D.02	Filters prototypes- full scale	H	End 2018
D.03	Experiment report : performance tests with selected pollutants done by the applicant	R	2019
D.04	Ageing tests report	R	2020
D.05	Experiment report : Performance test in integrated ECS system demonstrator	R	2020



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

- Skill 1 : Strong background in air treatment
-Skill 2 : Experimental bench for testing the performance and degradation of the said equipment with the selected pollutants

5. Abbreviations

VOCS : Volatiles Organic Compounds (excluding CO2)
E ECS : Electrical Envirnment Control System

VIII. Analysis, validation and parametric studies of design and operating parameters for modern cabin ventilation concepts related to future aircraft energy management systems

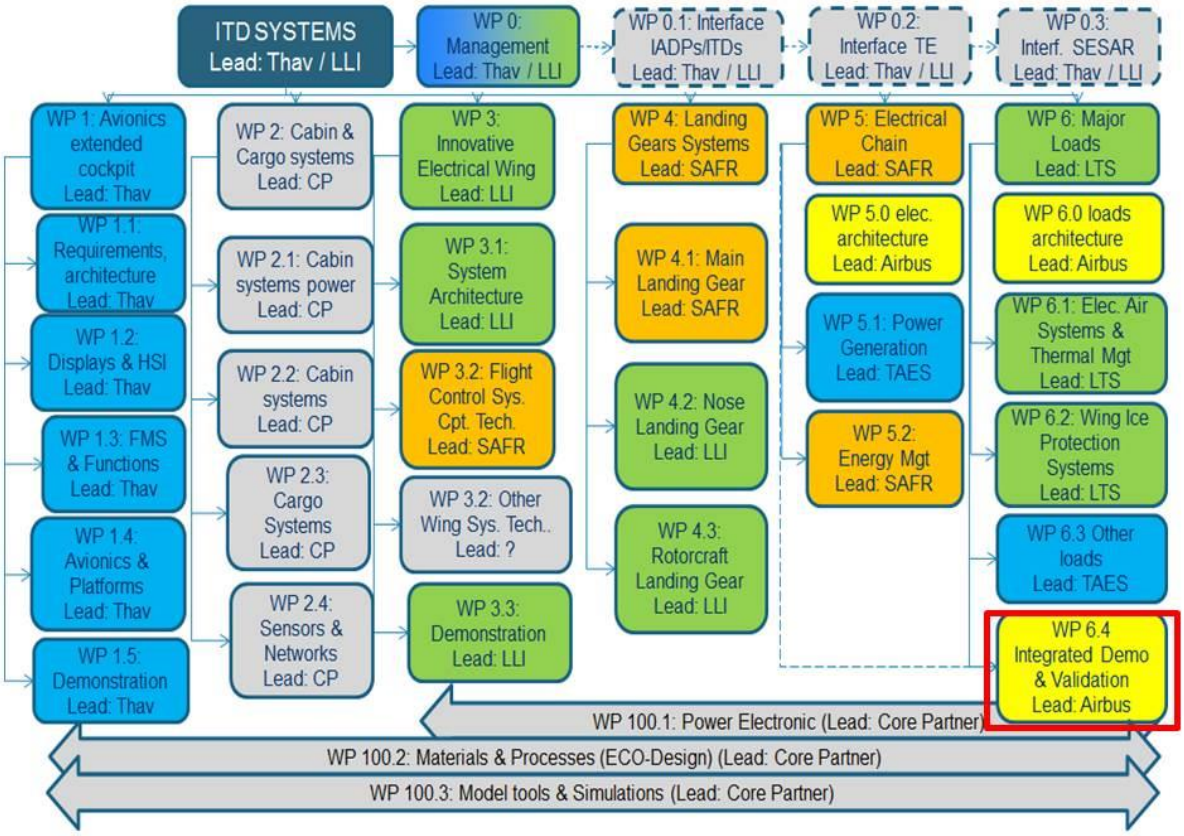
Type of action (RIA or IA)	IA		
Programme Area	SYS – WP6.4		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	2000 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	48 months	**Indicative Start Date**[61]	Q2 2017

Identification	Title
JTI-CS2-2016-CFP04-SYS-02-28	**Analysis, validation and parametric studies of design and operating parameters for modern cabin ventilation concepts related to future aircraft energy management systems**
Short description (3 lines)	
Future aircraft energy management systems, aiming at smart management of electric power and thermal loads at system level, will substantially impact the cabin fluid- and thermodynamics. Due to the complex boundary conditions of cabin fluid- and thermodynamics, experimental validation at full scale in cabin mock-ups and demonstrators are required.	

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

1. Background

In the context of advanced ECS and cabin ventilation there are potentially more degrees of freedom to achieve an energy optimized air conditioning operation. This includes steady state as well as transient thermal cabin behavior as well as an extended air management. The overall chain of the controlled system: ECS architecture – ECS operation & control – physical behavior of the cabin ventilation – occupant's thermal comfort perception needs therefore to be re-evaluated.
In this topic the special focus is on a sound and thorough investigation of the cabin ventilation and its analysis to provide the correct data for validation and verfication of the control architecture.



2. Scope of work

Future ECS (Environmental Control System) concepts are using a new air intake (scoop) for supply of fresh air. The splitting of powering and ventilation makes it possible to use larger control ranges leading to potential variations in temperature and mass flows for an energy-related utilization. To exploit these operating ranges it is essential to gain a deeper understanding about the thermodynamic behavior of the cabin interior and indoor climate. In this context the distribution of CO2 within the cabin is of fundamental interest.

The activities targeted by this call will take place in the frame of the Work package 6.4

The expected contribution from the applicant consists in three main tasks:

- Planning and design of a cabin mock-up in consideration of future long range aircraft concepts, based upon Airbus inputs
- Preliminary design and numerical optimization of the cabin ventilation system
- Experimental studies of cabin fluid- and thermodynamics related to future energy management systems

The high level planning of these tasks is the following:

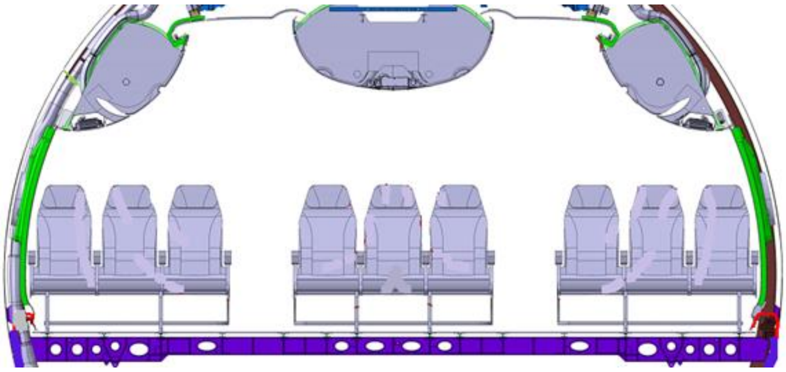
Tasks		
Ref. No.	***Title - Description***	***Due Date***
T_6.4.5.1	Planning and design of a cabin mock-up in consideration of future long range concepts	T0+24 months
T_6.4.5.2	Preliminary design and numerical optimization of the cabin ventilation system	T0+30 months
T_6.4.5.3	Experimental studies of cabin fluid- and thermodynamics related to future energy management systems	T24+24 months

T_6.4.5.1: Planning, design and realization of a fully representative physical cabin mock-up in consideration of future long range concepts (twin aisle)

Special aspects to ensure detailed cabin fluid- and thermodynamic investigations have to be taken into account. The level of realism should be adaptable to guarantee the best price/performance ratio:

- The mockup planning process shall consist of a preliminary design-, basic design- and detailed execution design phase. The results shall be presented and checked at the end of each intermediate design stage and finialized with the milestone (M_6.4.5_2).
- The mock up will be set up with the most realistic cabin parts to account for the correct heat exchange and heat storage effects for all surfaces and cabin seats/monuments (especially important for the dynamic testing)
- All cabin surfaces/floors participating in heat exchange shall have the possiblity to control the surface temperature/heat transmission by means of surface cooling/heating systems (e.g. water flown capillar mats)
- In order to account for 3D flow pattern effects the size of the mock shall not be smaller than 14 frames a 25” (0,635m) length and A350 inner cabin width (~5.4m). The final dimensions shall be agreed with Airbus.
- Ventilation systems able to switch easily between various configurations during each test shall provide temperature/humidification-controlled flow rates between 30l/s/m and 150l/s/m (tbc after the numerical pre-investigations and agreed with Airbus)
- Highly precise control and measurement of relevant mass flows and temperatures

- Consideration of modern design principles and materials to recreate boundary conditions of a modern long range fuselage (preferrably use of real aircraft cabin parts strongly recommended)
- Compliance with, adequate measurement techniques (PIV, thermography, tracer gas, etc.)



A350XWB cross section example

T_6.4.5.2: Preliminary design and numerical optimization of the cabin ventilation system

Preliminary investigations on suitable, new cabin ventilation configurations for future long range cabins (twin aisle) based upon Airbus inputs

- Unsteady CFD and thermal comfort simulations and investigations on appropriate and representative air flow systems
- Preselection of promising ventilation system design solutions, first integration and validation through mock up test.
- Based upon validation results, further optimization of models and components
- Numerical pre-examinations of the distribution of CO2 inside the cabin by means of tracer analysis

Due to the very complex flow phenomena occurring in typical twin aisle cabin layouts (long range aircraft) in conjunction with new ventilation methods, a profound validation of current numerical approaches has to be carried out. Numerical results shall be compared to flight test / ground test data or realistic a/c application lab test values to correctly predict all occuring flow phanomena.

T_6.4.5.3: Experimental studies of cabin fluid- and thermodynamics related to future energy management systems

Experimental investigations of the flow- and temperature fields in a future long range twin aisle cabin mock up considering state-of-the art and future cabin ventilation systems.

- Thermal passenger dummies for simulation of the cabin air flow with realistic obstructions, heat loads and buoyancy forces
- Measurement techniques to obtain instantaneous information about the flow fields and to improve the understanding of the fluid physical processes
- Determination of temperature distributions
- Assessment of the heat removal efficiency on the basis of highly precise measurements of air temperatures as well as different adjusted mass flows

- Infrared thermography to survey the influence of the particular ventilation setting on interior surfaces
- Variation of mass flows and inlet temperatures (steady and unsteady) to examine the effects on flow structures, temperature distribution, velocities, the comfort relevant flow parameters and the heat removal efficiency

Unsteady temperature changes to detect storage effects due to the heat capacity of the cabin interiorRecent aircraft air conditioning systems are designed to provide a constant outside air flow according to a fully occupied cabin. Very often special customer layouts or normal flight operations with decreased passenger number allow to reduce the outside flow without violating the certification regulations and the comfort keeping the cabin total flow constant (Air Management).
In this project efforts shall be made to investigate the potential outside and total flow reduction within Airbus cabins to even save more fuel.
In order to guarantee a sufficient global but also local air exchange at each passenger for the different new ventilation approaches contaminent removal effectiveness and local air echange index measurements shall be plannend and performed:

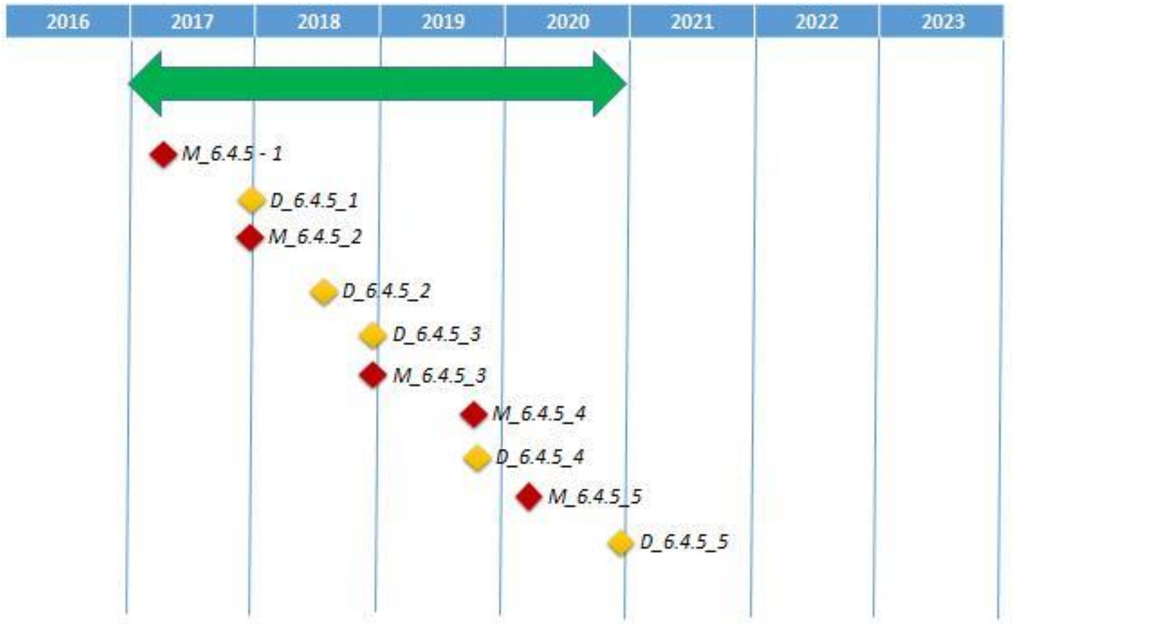
- Tracer gas analysis of the energetically most efficient configurations to determine the minimum possible mass flows to ensure cabin comfort requirements.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D_6.4.5_1	Planning document for used measurement techniques and test matrix	R	T0+12 months
D_6.4.5_2	Design documentation of optimized components	R	T0+18 months
D_6.4.5_3	Cabin mock up	D	T0 +24 months
D_6.4.5_4	First validation results report	R	T0 + 33 months
D_6.4.5_5	Processed measurement data and final report	R	T0+48 months

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M_6.4.5_1	Specification of requirements for a future long range cabin mock-up	RM	T0+3 months
M_6.4.5_2	Planning and design freeze for cabin mock-up	RM	T0+12 months
M_6.4.5_3	Mock-up and measurement techniques ready for testing, start of validation	RM	T0+24 months
M_6.4.5_4	First validation results	RM	T0+33 months
M_6.4.5_5	Optimized hardware available	RM	T0+39 months

Schedule:



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

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

- Proven expertise in the planning, risk management, erection and operation of aircraft cabin mock-ups.
- Profound understanding of cabin fluid- and thermodynamics as well as passenger's comfort prediction.
- Proven know-how of computational fluid dynamic methods and processes for optimal efficiency on high-performance computer clusters.
- Proven expertise in the modelling of turbulent flows using high-fidelity RANS and cabin comfort models and scale-resolving approaches (hybrid RANS/LES, LES)
- Proven expertise in the modelling and optimization of cabin ventilation systems by means of experimental and numerical studies of turbulent flows.
- Proven know-how in the simulation of the heat input from human passengers on the basis of heated thermo dummies
- Proven expertise in the measurement of convective air flows on large scales in aircraft cabins by means of advanced Particle Image Velocimetry (PIV) techniques

5. Abbreviations:

PIV - Particle Image Velocimetry
RANS - Reynolds-averaged Navier–Stokes equations
LES - Large eddy simulation

IX. An innovative Electrical Power Distribution System (EPDS) for Small Aircraft

Type of action (RIA or IA)	IA		
Programme Area	SYS – WP7.2.1		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	1000 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	36 months	**Indicative Start Date**[63]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-SYS-03-07	**An innovative Electrical Power Distribution System (EPDS) for Small Aircraft**
Short description (3 lines)	
A demonstrator of a complete EPDS prototype for Small Aircraft will be designed and manufactured, containing modules commanded and monitored in accordance with an intelligent power management system. Virtual and laboratory test benches will be used to identify problems and risks related to the selected architectures. The design and development of the said EPDS shall be based on high level specification defined by TM.	

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

1. Background

More electric aircraft is requiring increased electrical power availability also in the segment of small aircraft. This fact comes out by the pronounced trend of replacing mechanical, pneumatic and hydraulic equipment by others partially or completely based on electrical design. The immediate consequence of the above statement is to pose under discussion the conventional electrical power generation and distribution system wherein DC starter generators feed loads grouped on different busses according to the relevant criticality with respect to fly and safely land the aircraft. DC generation is normally limited by the high value of current involved when more than 12 kW are required on each engine driven generator. At the same time the classic distribution architecture automatically and progressively cut off loads/busses according to their priority as soon as power sources become unavailable in a fixed strategy without looking at flight phase or tailored requirements.
While generation slightly migrates towards powerful system the distribution retains a significant role as an intelligent power management could better exploit generation sources without necessarily increasing their rating. Future EPDS design cannot rely on the adoption of larger power sources intended to supply the simultaneous demand of all the consumers under normal operation. Also conventional load shed following generator failure(s) cannot be limited to shedding loads according to their criticality.
Brushless electric machines working as starter and generator can be controlled by analog/digital control units being the status of power sources continuously represented in the cockpit panels. So proper information regarding how each generator is feeding the distribution system can be sent also to an intelligent power management system (IPMS) in order to promote adequate load shed actions and to anticipate drastic power cut off due to overload conditions. Power converters satisfying different voltages and different type of electric power are available for installation in the electrical system architecture; such converters other than sending relevant information about their present mode of operation to an IPMS can feed solid state power controllers (SSPC) that replace conventional switching and protection devices; the SSPCs may grant flexibility referring to the tailoring of trip intervention curve and have the capability to be monitored via digital busses.
At the end the innovative combination of those hardware elements with adequate software resources could bring the opportunity to automatically coordinate power availability and consumers demand not only for discouraging the continuous growth of electric source size but also for maintaining crew workload at a reasonable level.

2. Scope of work

The activities proposed in this CfP are the design, development, manufacturing and preliminary test of an EPDS.

Tasks

The project will be divided in the following tasks.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 0	**Review** Main topics are: • to analyze key characteristics of the present EPDS • to evaluate actual constraints • to define boundaries of the new EPDS The TM is in charge to develop these activities. The applicant will benefit the results of the above analyses.	
Task 1	**High Level Technical Specification Drafting** The requirements for the future EPDS shall be defined in the HLTS after having collected information coming from different areas of involvement (e.g. system integration and interface, qualification and certification aspect, human machine interface, etc.).	T0+12
Task 2	**Preliminary Design** The applicant shall start the design defining the architecture and the main parts of the EPDS. Tradeoffs among different solutions and key characteristics of the selected architectures are parts of this task.	T0+14
Task 3	**Detailed Design** The applicant shall perform the design of all the parts integrated in the EPDS selecting most appropriate materials/technologies to realize the flow down of the high level requirements.	T0+18
Task 4	**Manufacturing** The applicant shall manufacture the EPDS also testing each unit part of the system in accordance with relevant ATPs. ATRs shall be made available for the next task to facilitate any comparison between stand alone and integrated behavior.	T0+24
Task 5	**Rig Test** The applicant shall submit the whole system to a significant test campaign in an integration rig where interfaced systems are provided in a manner suitable for the purpose of actual integration.	T0+32

Remarks: The opportunity to perform modeling activities for anticipating technical issues and risks associated to the selected architectures to be evaluated considering similar activities done in the SYS ITD

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Trade off study for Electrical System for SAT	R	T0
D2	EPDS Preliminary Studies	R	T0+6
D3	HLTS for EPDS	R	T0+12
D4	PDR Technical Documentation Package	R	T0+14
D5	CDR Technical Documentation Package	R	T0+24
D6	Acceptance Test Procedure(s) [each LRU]	R	T0+30
D7	Acceptance Test Result(s) [each LRU]	R	T0+32
D8	Rig Test Procedure	R	T0+38
D9	Rig Test Result	R	T0+40

T0 (TBC): assumed to be CfP issued (30/05/2016)

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M0	Kick-off Meeting	RM	T0+8
M1	Release of HLTS	R	T0+12
M2	PDR Activities Closure	RM	T0+14
M3	CDR Activities Closure	RM	T0+24
M4	LRUs availability	D	T0+32
M5	Rig Test Activities Closure	R	T0+40

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

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

The Applicant shall have:

- Experience in electrical systems of air vehicles
- Involvement with airframe industry
- Participation in R&T projects co-operating with industrial companies
- Experience in the design and manufacturing of aircraft LRU in the field of EPDS

- Experience with electrical modeling and simulation tools oriented to the design of electrical system LRU
- Experience in qualification and certification process in civil environment along with knowledge of military standard supporting the design and qualification of electrical system LRU
- Capability to design and set up Test Rigs
- Capability to support aircraft ground test activities

1. Abbreviations

A/C	Aircraft
AC	Alternate Current
ATP	Acceptance Test Procedure
ATR	Acceptance Test Result
CDR	Critical Design Review
CfP	Call for Proposal
CS2	Clean Sky 2
DC	Direct Current
EASA	European Aviation Safety Agency
EPDS	Electrical Power Distribution System
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulations
FMEA	Failure Modes and Effect Analysis
HLTS	High Level Technical Specification
HVDC	High Voltage DC
ICD	Interface Control Document
IPMS	Intelligent Power Management System
KOM	Kick-off Meeting
LRU	Line Replaceable Unit
PDR	Preliminary Design Review
R&T	Research and Technology
SAT	Small Aircraft Transport
SSPC	Solid State Power Controller
TBC	To be confirmed
TBD	To be defined
TRL	Technology Readiness Level

X. Electromechanical actuation of a landing gear

Type of action (RIA or IA)	RIA		
Programme Area	SYS – WP7.2.2		
Joint Technical Programme (JTP) Ref.	JTP V5		
Indicative Funding Topic Value (in k€)	1000 k€	**Type of agreement**	Implementation Agreement
Duration of the action (in Months)	36 months	**Indicative Start Date**[64]	Q2 2017

Identification	**Title**
JTI-CS2-2016-CFP04-SYS-03-07	**Electromechanical actuation of a landing gear**
Short description (3 lines)	
Development of electromechanical landing gear actuators including lock system, having redundant architecture for emergency extension, suitable for effectively reducing the complexity and weight of aircraft system with respect to conventional hydraulic system.	

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

1. Background

During the last years in the context of more electric aircraft the development of electromechanical actuation systems has increased rapidly.

The aim to introduce such technologies in the future is to reduce complexity and costs of a landing gear actuation system for SAT A/C's.

Safety issues are the more stringent requirements for EMA/ECU's which require redundant architectures to be fail-safe equipments.

Testability of the redundant components and health monitoring of all the mechanical components are features to be incorporated into the design in order to meet safety requirements.

Preferred health monitoring technologies to be introduced into the EMA are those that do not require adding new sensors / devices in the EMA.

2. Scope of work

The project will develop design architectures and cost effectiveness technologies, including health monitoring, to provide reliable actuation systems (i.e. EMA/ECU's) for N/M Landing Gear application.

The project will be divided in the following tasks and milestones, starting from the technical specification requirements list (T01), followed by EMA/ECU's possible architectures definition and technologies identification in parallel to meet the requirements (T08), after that the design, manufacturing and integration of the EMA/ECU's (T07), followed by verification tests (T08).

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T01	*Detailed technical specification for the landing gear actuation systems* The partner must concur with the Topic Manager in the definition of the system requirements (i.e. system components, performances, mass, envelope, reliability maintainability testability and safety, health monitoring strategy, validation tests). The detailed specifications will be agreed upon with the Topic Manager.	T0+2
T02	*Preliminary design of the landing gear actuation systems* The partner must provide preliminary studies supported by sketches and analyses in order to evaluate possible alternative arrangements. The technical specification will be frozen at the end of this phase.	T3 to T8
T03	*Technologies identification* The partner in parallel with the " *Preliminary design of the landing gear actuation systems"* shall present the technologies that intends to implement in the EMA + ECU to achieve the requirements. Impact of each proposed technology have to be assessed and weighed in terms of impact on weight, size and cost of the EMA.	T3 to T8

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T04	*Landing gear actuation systems preliminary design* The partner shall develop the EMA / ECU and ensure the construction, assembly and preliminary testing of the assembly.	T9 to T14
T05	*Landing gear actuation systems final design* The partner shall develop the EMA / ECU and ensure the construction, assembly and preliminary testing of the assembly.	T15 to T18
T06	*Landing gear actuation systems manufacturing* The partner shall develop the EMA / ECU and ensure the construction, assembly and preliminary testing of the assembly.	T19 to T26
T06	*Test Rig design and manufacturing* The partner shall design and manufacture a test rig suitable for testing the actuation systems.	T9 to T26
T07	*Landing gear actuation systems integration* The partner shall perform actuation system integration into the Test Rig.	T27 to T30
T08	*Landing gear actuation systems testing* The partner shall perform the validation tests in accordance with the technical specifications. Substantiation of health monitoring HW and SW will be demonstrated during the tests.	T31 to T35

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Detailed technical specification for the landing gear actuation systems	R	T0+2
D2	Preliminary design of the landing gear actuation systems. Technologies identification	R	T0+8
D3	Landing gear actuation systems preliminary design.	R	T0+14
D4	PDR of EMA/ECU's	RM	T0+15
D5	Landing gear actuation systems final design.	R	T0+18
D6	CDR of innovative EMA/ECU	RM	T0+19
D7	EMA/ECU's manufacturing and integration	D	T0+30
D7	EMA/ECU test report	R	T0+35
D8	Project final report	R	T0+36

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Detailed technical specification	R	T0+2
M2	Preliminary design and technologies identification	R	T0+8
M3	PDR of innovative EMA/ECU	RM	T0+15
M4	CDR of EMA/ECU	RM	T0+19
M5	EMA/ECU’s manufacturing and integration	D	T0+30
M6	EMA/ECU’s test report	R	T0+35

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

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

The Partner shall have:

- Previous experience in development and design of advanced technologies in the field of Electromechanical Actuation Systems.
- Proven experience in international R&T projects cooperating with industrial partners, institutions, technology centers, universities.
- Quality and risk management capabilities demonstrated through applications on international R&T projects and/or industrial environment
- Proven experience in the use of design, analysis and configuration management tools of the aeronautical industry
- Acknowledge participation to air vehicle developments with experience in “in-flight” components and laboratory set-up for aeronautical certification.
- Electrical and mechanical installation and integration.
- Knowledge and experience in health monitoring techniques.
- Test rig design
- Instrumentation data acquisition, recording and monitoring.